Continuous Linked Settlement: History and Implications

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Alexandra Schaller
from Bösingen FR

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Prof. Dr. Hans Geiger
Prof. Dr. Rudolf Volkart

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Contents

List of Figures

List of Tables

Chapter 1

Introduction

Post-trade processing is not a glamorous topic. For most people, clearing and settlement is not of much interest. As a result, the post-trade industry is widely unknown except for the professionals who use and provide post-trade services. On the academic side, comprehensive literature can be found on asset pricing, trade volume, and trading arrangements. Only few work, however, is done on the industrial organization of post-trade activities. Considering the large amounts of economic resources that are consumed by post-trade clearing and settlement processing, the area is under-researched. This thesis is a contribution to the academic literature regarding post-trade activities in the foreign exchange market. The international foreign exchange market is the largest market in the world. Its volume is six times the trading volume of the second largest market, the U.S. Treasury securities market. Since there are always two parties to each foreign exchange transaction, the volume to be settled is even twice the trading volume. In foreign exchange trading, it is not uncommon for two banks to owe each other 2 billion US Dollar overnight because settlement has not yet been completed. The figures make clear that reliability and resilience of the settlement processes are essential. Interruptions or delays may have disastrous consequences for the financial industry. During the past years, financial authorities have started to realize the system's vulnerability and increasingly paid attention to post-trade activities in general and to settlement practices of foreign exchange in particular. In the nineties, several publications have highlighted that most banks had tremendous overnight credit risk exposures due to current settlement and reconciliation practices at that time. Regulators called on the financial industry to take appropriate action to measure and reduce the settlement risks in the foreign exchange market. Since then, the international financial industry has heavily invested in operations and technology to comply with regulators' requests. The most important result from these common industry efforts is the implementation of the Continuous Linked Settlement (CLS) system. Briefly, CLS is specifically designed to eliminate credit risk on foreign exchange transactions that it settles. A payment-versus-payment settlement mechanism combined with a number of risk management provisions eliminates credit risk exposures. The elimination of credit risk, however, brought a number of other changes to the market. This thesis deals with the most important aspects of the CLS system in general and its implications for the market.

1.1 Scope

The scope of this thesis is to describe and analyze the characteristics of the CLS system. Brief documentations regarding the system's functionality can be found in several public articles. This thesis, however, provides not only an in depth description of its functionality but also documents the history of its implementation in detail and looks insight its transaction structure. The goal of this thesis can thus be split in four parts: (1) Provide a description of CLS' history, (2) deliver an in depth description of its functionality, (3) assess CLS's achievement in reducing credit risk, and (4) analyze the evolvement of its transactions structure and pick up some liquidity issues. These four parts together form a comprehensive overview of the CLS system. It must be mentioned that this thesis does not explicitly focus on operational risks or corporate governance issues nor on systemic risk aspects. They may be a component part of the thesis but are not addressed separately.

1.2 Design

The thesis is organized as follows. **Chapter 2** provides the reader with the basic knowledge that is necessary to understand the subsequent chapters. It explains the term settlement and introduces the main operational features inherent to settlement systems. It sets the theoretical basis of net- versus gross settlement and shows their interrelation. It then narrows its focus to the specialties regarding the settlement of foreign exchange transactions and introduces the domestic settlement systems that are of interest to CLS. Equipped with the basics of settlement, the reader gets acquainted with the general environment of CLS. **Chapter 3** starts off with an overview of the global foreign exchange market, its products and its post-trade processing. The publications of the Bank for International Settlements (BIS) and the description of several market disruptions show the emergence of public interest regarding foreign exchange settlement processes. Public interest and regulatory pressure are identified as the main drivers for the industry's motivation to lower settlement risks and improve systemic resilience. These incidences are important in the context of this thesis as they represent the prerequisites for the creation of the CLS system. Based on original minutes and protocols, **chapter 4** reproduces the history of the CLS system. The project started with the so called group of twenty banks (G20) that established a number of working groups to confirm the viability of such a system. In 1997 a company, CLS Services Ltd., was incorporated to fund and build the CLS system. The chapter reveals the chronological development of the system by taking up the key milestones and major difficulties that were encountered. Chapter 4 ends with the system going live in September 2002 and the renegotiation of the service agreement. **Chapter 5** describes the design of the CLS system in detail. Besides the corporate governance and the membership structure, it explains the funding and settlement processes as well as CLS' risk- and liquidity management framework. **Chapter 6** is dedicated to the question of how successful CLS has accomplished its main goal, the elimination of credit risk. It must be mentioned that the chapter suffers from a lack of data, as only a few figures are publicly available. Although chapter 6 does not provide a detailed empirical analysis, it clearly conveys CLS' success. Chapter 2 to 6 together offer a comprehensive evaluation of CLS and represent the first three parts of this thesis' goals. The fourth goal, the analysis of CLS' transaction structure is met in **chapter 7 and 8**. These chapters apply a real world network model approach to a set of empirical transaction data provided by CLS. Chapter 7 allows insights into the development of the relationships between CLS' participants. Chapter 8 suggests some findings regarding the liquidity dynamics within the system. **Chapter 9** offers a critical conclusion of the thesis and addresses further research areas.

Chapter 2

Basics of Settlement

Chapter 2 provides a general introduction to clearing and settlement with a focus on the settlement of foreign exchange contracts. It presents the main definitions and theoretical concepts to prepare the reader for the following chapters.

2.1 Scope of Clearing and Settlement

Clearing and settlement are post-trade processes to perform contractual delivery obligations such as securities or payments. Clearing refers to the process of transmitting, reconciling and, in some cases, confirming payment orders or security transfer instructions prior to settlement. It may also include the netting of instructions, the establishment of final positions for settlement, and the modification of contractual obligations (CPSS 2003). Settlement represents the actual discharge of the obligations of buyer and seller through the transfer of funds and securities (Perold 1995). While in a security transaction securities are exchanged against payment, a foreign exchange transaction involves two payments and no securities. A foreign exchange transaction is therefore said to have two cash legs. As settlement of securities is not subject of the subsequent chapters, it is not addressed any further. The following sections focus on the settlement of payments between banks only. Regarding the functionality of settlement systems, it is distinguished between two main technologies, real-time gross settlement (RTGS) and net settlement systems. Before presenting a detailed description of these two mechanisms it is looked at four operational and structural features that concern both types of systems. It is this: (1) the attribute of settlement finality, (2) the characteristics of a payment versus payment (PvP) mechanism, (3) the provision of performance guarantee, and (4) settlement risk aspects.

2.1.1 Settlement Finality

Since the 1970ies central banks have been concerned with systemic risks of financial markets (see 3.3). Settlement finality is an important aspect regarding systemic stability in payment systems. It ensures that at some point the transfer of payments is complete and cannot be reversed under any circumstances such as failure or bankruptcy of the involved parties. Settlement is said to be unconditional and irrevocable. It assures that also in times of a financial system crisis, transactions are settled with finality (Pagè & Humphrey 2005). In absence of settlement finality an already processed transaction might be reversed, for instance in case of bankruptcy of one of the counterparties. The reversion would cause an unwinding of all interrelated transactions and some of the affected counterparties might have to repay funds. This, in turn, could lead to a liquidity crisis that threatens the stability of the whole system. Whether settlement finality is ensured in a particular system depends on the legal validity and enforceability of transfers in a specific country, together with the rules of the settlement system itself (Perold 1995).

2.1.2 Payment versus Payment

Under a payment versus payment (PvP) settlement standard, funds of two counterparties are transferred simultaneously and one transfer is only considered final if the counter-transfer is final as well. PvP thereby eliminates the most important settlement risk, where one counterparty transfers the owed funds without receiving the counter-payment. This type of settlement risk is often called principal risk (see 3.1.4). Principal risk may exist in any settlement procedure when the two transaction legs are treated asymmetrically (Perold 1995). Foreign exchange transactions in particular show an inherent asymmetry due to the fact that the involved payment systems are often located in different time zones and therefore have different opening hours. To achieve a PvP mechanism the opening hours of the involved payment systems must be overlapping (see 2.4.3). In securities settlement the analogue concept is called delivery versus payment (DvP).

2.1.3 Provision of Performance Guarantee

A settlement institution that provides clearing and guarantees the execution of a transaction is called a central counterparty (CCP). It substitutes itself as a buyer to the seller and as a seller to the buyer (Perold 1995). The original contractual relationship between the two counterparties are replaced by respective contracts with the CCP. This contract substitution is called novation. It results in a homogenization of all payments or contracts. Contract novation does not remove counterparty credit risk from a market, but it reallocates risks in that participants' bilateral risk exposure is replaced by a standard credit risk to the CCP. As it guarantees post-trade anonymity, central counterparty clearing is most common in derivative markets and increasingly also in equities markets (Ripatti 2004).

2.1.4 Settlement Risk

Generally speaking settlement risks stem from payment system participants' failures to fulfill their obligations on time and lasts from the time of the trade up to final settlement. It must be noted that a number of varying definitions and names for settlement risk and its corresponding phases can be found in literature. The following brief outline adheres to the doctrine represented by Geiger (2007) and identifies 3 different types of risks that occur during the settlement process. For a more detailed description of these phases refer to section 3.1.4, notably to figure 3.2 on p. 33. During the settlement process different kinds of risks arise with different stages of failure. A settlement system participant is exposed to (1) liquidity risk due to the possibility that its counterparties may fail to meet their obligations in a timely manner. This would change the participant's expected liquidity position as the owed funds would not be received on time. The delay may force the participant to cover its cash flow shortage by funding from other sources which may result in higher cost (BIS 1997). The possibility that the counterparties do not fulfill their obligations at all generates (2) credit risk for that settlement system participant. Credit risk is also called principal risk or Herstatt risk and denotes the risk of losing the full value of the contract. Credit risk can be eliminated by a PvP mechanism. Both, late or non-fulfillment of obligations forces the participant that expected the payments, to replace the missing funds. This creates (3) market risk. The more time elapses between trading and settlement the longer the exposure of a participant to market risk. Besides these three types of settlement risks, credit risk, liquidity risk, and market risk, also operational risks and legal risks may arise. These kind of risks are not discussed any further. As mentioned earlier, a more detailed description and illustration of the emerging risks during the settlement of foreign exchange contracts can be found in 3.1.4. The extent to which a participant is exposed to settlement risk depends on the time lag between the trade and final completion, the principal amount of the contract to be settled, and the probability of failure occurrence. As the incidence rate for failure in settlement is very small but the damage in case of occurrence high, settlement risk can be compared to natural hazards. Especially in foreign exchange trading where the face values of the contracts may be higher than the counterparties capital, controlling settlement risk is critical. Common risk measures such as value-at-risk models do not adequately replicate reality. A great deal of research has been done on how to measure and reduce or eliminate settlement risk. An interrelated and also extensively discussed topic is systemic stability. To analyze these topics, models and simulations are usually applied to either one or both different types of systems: real-time gross or net settlement systems.

2.2 RTGS versus Net Settlement

The following description of the two basic technologies for settlement, real-time gross settlement and net settlement, is based on Riedl (2002). Both types settle payment obligations among their participants but use a different calculation mode. Payments may be represented in an $N \times N$ matrix with N being the number of system participants. A payment from a sending bank i to a receiving bank j at time t is denoted $w_{ij,t}$ with $(i \neq j)$. A particular system participant is represented by k.

2.2.1 Real-Time Gross Settlement

Systems operating under a real-time gross settlement (RTGS) mode continuously settle the entered payment instructions by transferring reserve funds from the paying bank to the receiving bank during the day. Hence, under RTGS each payment $w_{ij,k}$ is settled separately. If a participant exchanges payments with all other participants in the system at any possible time t with $t = 1, 2, \ldots, T$, the maximum number of payments to be settled for that particular participant k is described as $T(N-1)$. As this is true for each participant, the maximum number of settlement positions is $NT(N-1)$. Total gross settlement volume SV^g per business day is calculated as:

$$SV^g = \sum_{ij} \sum_{i=1}^{T} w_{ij,t} \quad \forall\ i, j = 1, \ldots, N;\ i \neq j \tag{2.1}$$

To settle payment instructions, the system simultaneously debits and credits the sending and receiving bank's central bank transaction accounts. For immediate and final execution of a payment instruction received from a sender bank, sufficient funds must be available on the relevant sender bank's account. If this is not the case, the RTGS system may either reject the instruction or put it into a queue until the end of the business day. The queued instructions get settled as soon as sufficient funds are available on the sender bank's transaction account. The necessary liquidity is provided by incoming payments or by the sender bank depositing additional funds to its transaction account. The minimum net liquidity demand L^g of a particular bank k participating in an RTGS system with a queue facility is therefore the difference between its total payment obligations and its total payment receipts:

$$L_k^g = \left| min \left\{ 0; \left(\sum_i \sum_{t=1}^{T} w_{ik,t} - \sum_j \sum_{i=t}^{T} w_{kj,t} \right) \right\} \right| \qquad \forall\ i, j = 1, \ldots, N;\ i \neq j \tag{2.2}$$

An RTGS system without a queue facility tends to request more liquidity to settle instructions upon receipt as at any point in time during the day the cumulated payments received must be greater than the cumulated payment obligations, otherwise additional liquidity must be deposited. The amount of additional liquidity that is needed compared to an RTGS system with a queue facility depends on the value of the incoming and outgoing payments and their order.

2.2.2 Net Settlement

The second type of settlement system operates under net settlement rules. During the day participating banks transmit their payment instructions either directly to the settlement agent (i.e. the institution that manages the settlement process) or to a clearinghouse for processing and subsequent settlement. At specified points in time, usually the end of the business day, the system calculates the net value of all payments due to and due from each participant in the system. Banks with net debit positions transfer funds to the system which in turn books these reserve funds to the accounts of the net creditor banks (Kahn & Roberds 1998). Hence, in contrast to the mechanism of an RTGS system, netting systems only settle at a determined number of settlement periods, often only once a day. Settlement becomes final during these settlement periods. During the pre-settlement period when the system performs matching and netting calculation, instructions are revocable and thus not yet final. If the netting system does not provide performance guarantee, participants are exposed to settlement risk during this phase. Provided formal netting contracts and a sound legal basis, it is only the net position that is at risk (BCBS 2000). For that reason netting arrangements are said to reduce pre-settlement risk. In addition, netting systems organized as CCP's and thus providing performance guarantee exhibit a characteristic called post-trade anonymity which is an important feature in securities settlement. It assures that the buyer of a security does not know its seller. For the settlement of foreign exchange contracts this is not a relevant feature. In general it is distinguished between bilateral netting and multilateral netting.

Bilateral Netting

In a bilateral netting system, payment instructions are netted for each pair of participants. The maximum number of payment obligations for a particular participant k is $(N-1)$. The sum of the bilateral net positions NP^{n_b} for participant k that need to be settled at the end of the business day T is represented by:

$$\begin{aligned} NP_k^{n_b} &= \sum_{ij}\left(\sum_{t=1}^{T} w_{ik,t} - \sum_{t=1}^{T} w_{kj,t}\right) \\ &= \sum_{i}\sum_{t=1}^{T} w_{ik,t} - \sum_{j}\sum_{t=1}^{T} w_{jk,t} \\ &\forall\ i,j,k = 1,\ldots,N;\ i = j \neq k \end{aligned} \tag{2.3}$$

Accordingly, the net liquidity requirement L^{n_b} for participant k at the end of the business day T under bilateral netting amounts to:

$$L_k^{n_b} = \sum_{ij}\left| min\left\{0; \left(\sum_{t=1}^{T} w_{ik,t} - \sum_{t=1}^{T} w_{kj,t}\right)\right\}\right| \qquad \forall\ i,j,k = 1,\ldots,N;\ i = j \neq k \tag{2.4}$$

On system level the total number of transactions that has to be settled at the end of the business day T amounts to $\frac{1}{2}N(N-1)$. Total bilateral net settlement volume SV^{n_b} per business day in the system is calculated as:

$$SV^{n_b} = \frac{1}{2}\sum_{k}\sum_{ij}\left|\left(\sum_{t=1}^{T} w_{ik,t} - \sum_{t=1}^{T} w_{kj,t}\right)\right| \quad \forall\ i,j,k = 1,\ldots,N;\ i = j \neq k \tag{2.5}$$

Multilateral Netting

In a multilateral netting system payment instructions are netted among all participants. For each participant it results in a single payment obligation at the end of the business day T. This multilateral net position NP^{n_m} to be settled for a participant k is represented by:

$$NP_k^{n_m} = \sum_i \sum_{t=1}^{T} w_{ik,t} - \sum_j \sum_{t=1}^{T} w_{kj,t} \quad \forall\ i,j = 1,\ldots,N;\ i,j \neq k \tag{2.6}$$

Looking at equation 2.3 makes clear that the multilateral net position represented in equation 2.6 is the sum of all bilateral net positions. The net liquidity needs L^{n_m} for participant k at the end of the business day T under multilateral netting is then represented as:

$$L_k^{n_m} = \left| min\left\{ 0; \left(\sum_i \sum_{t=1}^{T} w_{ik,t} - \sum_j \sum_{t=1}^{T} w_{kj,t} \right) \right\} \right| \\ \forall\ i,j = 1,\ldots,N;\ i,j \neq k \tag{2.7}$$

The liquidity needs for a participant of a multilateral netting system as displayed in equation 2.7 is equivalent to the liquidity need of a participant of an RTGS system in which all transactions are queued and settled at the end of the business day T (see equation 2.2). The difference is that the multilateral netting system settles the net positions with a single payment for each participant while the RTGS system processes each instruction sequentially and infinitely close to T. For the participants, however, the resulting liquidity requirements are equal. This shows that the settlement delay, meaning the time between a payment instruction is entered to a system until it is settled with finality, is the crucial element that relates RTGS and netting systems.

Interrelation of RTGS and Net Settlement

It is clear from the previous sections that the number of transactions, the total transaction volume, and the liquidity need for a participant as well as for the system as a whole decreases from RTGS to bilateral and multilateral netting systems. One of the most important advantages of netting systems compared to RTGS systems noted in literature is the reduction of liquidity requirements. It reduces liquidity and transaction costs due to the aggregation of transaction and time discrete settlement. If cost savings were the only effect it would be reasonable to delay settlement to infinity. The financial industry, however, is pursuing to shorten settlement delay. In a netting system, payment instructions are not settled with finality until the end of the business day T. Depending on the time when an instruction is transmitted to the netting system it takes several hours until final settlement is completed. During this time period events may occur that frustrate successful settlement. Hence, while saving liquidity and transaction costs, netting systems prolong the time period during which participants bear settlement risk. For a detailed discussion regarding the trade off between risk and liquidity cost see Angelini & Giannini (1993). In practice the tendency to shorten settlement delay may be explained by technological innovations, decreasing transaction costs and increasing competition between settlement institutions. Most large-value transfer systems today are operated as RTGS systems. Settlement delay is approaching zero and thereby reducing settlement risk. A trade off between settlement risk and the need for intra-day liquidity can still be noticed. Today most central banks provide intra-day liquidity in terms of overdraft facilities subject to interest and backed by collateral. Liquidity is therefore not for free but costs interest and generates opportunity costs.

2.2.3 System Stability Aspects

Systemic risk is the risk that the failure of one participant to meet its required obligations when due may cause other participants to fail to meet their obligations when due. In extreme cases a chain reaction may be triggered threatening the entire system. Systemic risk arises from intra-day failure or delayed payments of settlement system participants. As liquidity is costly, participants try to keep liquidity as low as possible. As incoming payments are the source for liquidity at the lowest cost, participants may have incentives to settle their obligations only after they have received the necessary liquidity from incoming payments (Bech & Soramki 2001). This may lead to participants temporarily holding less liquidity than needed and thus, in some cases to payment delays. The participant is then not able to fulfill its obligation on time and with that retards the fulfillment of the obligation of other participants. In net settlement systems all instructions from the failing member must be deleted and the net debit positions of all members recalculated. This process is called unwinding. It may occur that due to the recalculation other members as well face a liquidity shortage as their net positions have changed significantly. The unwinding process is repeated until the remaining participants are able to fulfill their obligations. In RTGS systems it may occur that due to one instruction that does not get settled because of missing funds of that participant, the settlement of a number of other instructions in the queue is frustrated as well. The RTGS system is said to become illiquid and the corresponding state is called a gridlock. The Bank for International Settlements defines a gridlock as a "situation that can arise in a funds or securities transfer system in which the failure of some transfer instructions to be executed (because the necessary funds or securities balances are unavailable) prevents a substantial number of other instructions from other participants from being executed" (BIS 1993). This is mostly caused by some kind of liquidity shortage of one or more participants. Thereby, it might not only be the participants lacking liquidity management that causes the shortage but also an adverse allocation of the liquidity in the system. An unequal distribution of debits and credits, meaning that some participants have to bring up much more liquidity to fulfill their payments than others, may cause one or more participants to miss their payment obligations. Also the sequence of the payments in the queue determines the participants' liquidity needs. To minimize the risk for a gridlock the provision of intra-day liquidity by central banks is crucial. A number of historical gridlock situations is described in section 3.2.

2.3 Settlement Problems in Foreign Exchange

Settlement of foreign exchange contracts exhibits a number of particularities that are presented in the following. Most issues are based on Perold (1995). The basic problem of settling foreign exchange contracts is caused by the very nature of such a contract usually involving two currencies from two different countries that settle therefore in two different local payment systems that might be located in two different time zones. The two legs of the transaction can then not settle simultaneously because due to the time lag not both relevant payment systems are open. Without overlapping opening hours simultaneous settlement is impossible and credit risk is created. In the context of foreign exchange this kind of credit risk is often called Herstatt risk, named after the "Bankhaus Herstatt" (see 3.2.1). It is best explained by assuming a Yen/US Dollar transaction. If a Japanese bank sells Japanese Yen (JPY) and buys US Dollar (USD) from a US bank, it transfers the Yen via the local Japanese payment system to the US bank's correspondent in Japan. This must happen during the opening hours of the Japanese payment system. However, the US bank can only transfer the owed Dollars during the opening hours of the local US payment system. While fulfilling its Yen obligation, the Japanese bank will not know whether the US bank will accomplish the owed Dollar payment. The Japanese bank is exposed to Herstatt risk to the full amount of the contract.

2.4 Potential Solutions

A number of potential solutions was proposed in literature to solve the problem of Herstatt exposure. According to Perold (1995), three basic approaches are presented in the following: money market fund shares, contracts for differences, and extension of RTGS systems' opening hours.

2.4.1 Money Market Fund Shares

One approach that was brought up in the nineties was the idea of money market fund shares (Perold 1995). The proposal was based on a system of money market funds for each currency. Participants willing to enter a currency exchange would buy shares of the respective money market fund. At a mutually agreed point in time, the parties would exchange their shares of the relevant funds. The new owners of the shares could subsequently redeem the shares or use them for future currency exchanges. As an example, assume trader A who needs to pay 1 million US Dollars to trader B which in turn owes 100 million Yen to A. In such a system, trader A would purchase shares worth 1 million US Dollars in the US Dollar money market fund during the opening of the US payment system. Trader B would buy shares of the Yen money market fund worth 100 million Yen during the Japanese payment system operating hours. Once both traders have completed their purchase, they can exchange the shares at any time without consideration of the payment systems' operating hours. This solution effectively eliminates Herstatt risk as the transactions in the local payment systems as well as the exchange of shares can be accomplished through a DvP mechanism.

2.4.2 Contracts for Differences

An alternative idea was to settle foreign exchange transactions through so called contracts for differences (CFDs) (Perold 1995). These derivative products allow traders to settle their foreign exchange transactions without principal payments. Only the net gain or loss due to changes in the currency rates is transferred. An example of such a CFD is the rolling spot currency futures contract available at the Chicago Mercantile Exchange (CME) or the deferred spot forex futures contract at the Singapore International Monetary Exchange (SIMEX). These contracts are designed to deliver exactly the same payoff as would be obtained by holding an overnight spot currency position. To understand this mechanism some background regarding overnight rolling of spot currency positions is necessary and best explained using an example. Suppose, trader A buys US Dollars for Euros (EUR). To do so, trader A borrows the necessary Euros and subsequently lends out the bought US Dollars on a rolling overnight basis which means that the positions are closed and reopened at the end of each business day. The contract is finally closed out by selling the US Dollars and repaying the Euro loan. The overnight rolling of the position generates a daily cash outflow in Euros from the repayment of the Euros borrowed, and a daily cash inflow in US Dollars from the US Dollars lent. Additionally, the US Dollars and the Euros get re-lent and re-borrowed on a daily basis respectively. This results in four cash flows: one pair of in- and outflows for each of the two currencies. These flows are achieved using so called overnight foreign exchange swaps (i.e. a spot transaction combined with an opposite one day forward transaction, see 3.1.1). The net daily pay-off of this process is the amount by which the currency moves in excess of the lending/borrowing rate differential which can be interpreted as the opportunity cost of holding the position overnight (often called cost-of-carry or finance charge). For better understanding the example is reconsidered on a numerical basis.

Overnight rolling of a spot currency position

A trader buys 1'000'000 US Dollars at a bid rate of EUR/USD = 0.7800. To do so the trader borrows EUR 780'000 and subsequently lends out the bought USD 1'000'000. It is further assumed that the trade day's closing rate is EUR/USD = 0.7822, and that the position is closed out the next day at an ask rate of EUR/USD = 0.7830. The annual borrowing rate for Euros shall be 3 percent and the deposit rate for US Dollars 2.5 percent. These transactions trigger the following net cash flows:

Overnight interest rate differential

Daily interest payment on borrowed Euros:
780'000 EUR * 3% / 360 days = 65.00 EUR
Daily interest receipt on lent US Dollars:
1'000'000 USD * 2.5% / 360 days = 69.44 USD = 54.17 EUR
Total interest rate differential:
54.17 EUR - 65 EUR = **-10.83 EUR**
The trader's account is debited with 10.83 EUR for holding this position overnight.

Currency movement

As the closing rate for the rolling over equals EUR/USD = 0.7822, the trading profit for that day amounts to:
(0.7822 - 0.7800) * 780'000 EUR = **1'716.00 EUR**

Closing out

The position is closed out the next day at a rate of EUR/USD = 0.7830 yielding a trading profit of:
(0.7830 - 0.7822) * 780'000 EUR = **624 EUR**

Trade Summary

The net gain of this position is thus:
1716.00 EUR + 624.00 EUR - 10.83 EUR = **2'329.17 EUR**
The same result is obtained if the interest rate differential as well as the currency movement are calculated directly:
Interest rate differential = (2.5% - 3%) * 780'000 EUR/360 days = -10.83 EUR
Currency movement = (0.7830 - 0.7800) * 780'000 EUR = 2'340.00 EUR
Which results in the same net gain of **2'329.17 EUR**.

Derivative products like the rolling spot currency futures contract exactly replicate the net gain or loss of positions like the one described in the example. Instead of transferring the principal amounts for buying and selling, the currency traders only pay the price of the contract. The contract then requires the parties to settle daily on the overnight interest rate differential. Because this is done separately, the price of the contract itself only varies with movements in the currencies. These two elements together equal exactly the net payoff of the overnight spot currency position explained above. The difference between the rolling spot contract and the overnight spot currency position as explained in the example is that in the rolling spot contract there are no principal amounts that need to be settled. The contract eliminates Herstatt risk by replicating the payoff from an overnight spot currency position, but without requiring the payments of the principal amounts. Therefore, derivative instruments may serve as functional substitutes to reduce settlement risks. However, even though approximately 80 percent of all foreign exchange transactions are trades that do not require the delivery of the principal amounts, there are still about 20 percent that do require the delivery of the underlying currency for commercial reasons. These trades cannot be settled by derivative products and require respective counterparties that are willing to deliver the currencies. This market dynamic, leading to a chain reaction, is considered to be the main reason for derivative products of this type not to be able to penetrate the market (Klein 2006).

2.4.3 Extension of Payment Systems' Opening Hours

Actually the most evident approach is to extend the opening hours of all relevant payment systems. Overlapping opening hours would then allow for a PvP settlement mechanism. As described in the following chapters this was the prevailing solution and a prerequisite to develop the CLS system (see chapter 4). In the following, the 15 currencies settling in CLS and the large-value payment systems of their corresponding countries and SWIFT are introduced.

2.5 CLS Currencies and Payment Systems

2.5.1 United States Dollar and Fedwire

There are two major large-value payment systems operating in the United States. The Fedwire funds transfer system (Fedwire), operated by the Federal Reserve Bank, is an RTGS system. The Clearing House Interbank Payment System (CHIPS), a net settlement system, is operated by the Clearing House Interbank Payments Company. Fedwire enables its participants to send and receive final US Dollar payments in central bank money on an RTGS basis. To participate, an account with the Federal Reserve Bank (FED) is required. Payment instructions are settled individually during the opening hours from 00:30 to 18:30 Eastern Time (ET) which corresponds to 06:30 and 00:30 Central European Time (CET). CHIPS was a former end-of-day multilateral net settlement system that has been converted to a system that continuously matches, nets and settles US Dollar payment orders. It provides real-time finality for the payment instructions that are released from the CHIPS payment queue. Real-time processing is achieved by settling on the books of CHIPS against positive positions or by simultaneous offsetting of incoming payment instructions. To facilitate this process, the Federal Reserve Bank of New York has established a special CHIPS account. Participants must fulfill an opening position requirement (at no later than 09:00 ET (15:00 CET) with that account. Funds to this account are transferred via Fedwire and are subsequently used to settle the payment instructions throughout the day. CHIPS and Fedwire both open operations at 00:30 ET (06:30 CET). CHIPS, however, closes at 17:00 ET (23:00 CET) (BIS 2003*h*). CHIPS, being a netting system, does not offer the prerequisites to transfer funds to CLS. CLS therefore, is connected to Fedwire and holds an account with the FED.

2.5.2 Euro and TARGET

The Trans-European Automated Real-time Gross settlement Express Transfer (TARGET) system is the RTGS system for the central banks of the European Union (EU). It is a decentralized system comprising 16 national RTGS systems, also including the RTGS systems of the four EU countries that have not adopted the Euro (Denmark, Sweden, Poland and UK). The national RTGS systems are connected through so called Interlinking accounts. A project named TARGET2 is under construction at the moment. The current decentralized system is planned to be consolidated by introducing a so called Single Shared Platform at the end of 2007 (European Central Bank 2007). To initiate a payment, the payment instruction is sent to the national central bank via the domestic RTGS system. Once the central bank has checked the validity of the instruction, the amount is debited to the domestic RTGS account of the sending bank and credited to the Interlinking account of the receiving national central bank. After the receiving central bank has as well checked the instruction, it converts it from the Interlinking standard into the appropriate domestic standard, debits the Interlinking account and credits the domestic RTGS account of the receiving bank. Processing hours are from 07:00 CET to 18:00 CET. During that time payment instructions are exchanged on a bilateral basis as described above. The European Central Bank (ECB) ensures the correctness of the payments only at the end of the day by checking that all bilateral messages sent by one central bank to another have been received and that the sum of all received payments equals the sum of all sent payments. None of the participating central banks may close before the ECB has finalized the positions with all bilateral partners (BIS 2003*a*). CLS Bank holds an account with the ECB. All Euro payments from and to CLS Bank are processed via this ECB account and thus via TARGET (European Central Bank 2006).

2.5.3 Pound Sterling and CHAPS

CHAPS is an RTGS system and the main interbank payment system for large value transactions in the UK since 1996. To settle Euros, CHAPS Euro was introduced in 1999 and connected to TARGET (see 2.5.2). In 2001 a new technical platform provided by SWIFT (see 2.5.16) was introduced to link the two systems, CHAPS Sterling and CHAPS Euro. Today, CLS Bank holds an account with the Bank of England and is connected to CHAPS. To initiate payments, participants send appropriate SWIFT messages to the SWIFT network which forwards a settlement request to the Bank of England. If the sending participant has sufficient funds on its central bank account the transaction is settled by debiting its account and crediting the receiving participant's account at the Bank of England. As soon as the confirmation of this process has arrived at the SWIFT network, a corresponding message is sent to the receiving participant. CHAPS opens at 06:00 Greenwich Mean Time (GMT) and closes at 17:00 GMT (BIS 2003*g*).

2.5.4 Swiss Franc and SIC

Payments in Swiss Francs (CHF) are settled in an RTGS system called Swiss Interbank Clearing (SIC). As there are no value limits to the transactions the system can be considered as both, a large-value payment system and a retail payment system. It settles interbank payments in Swiss Francs with immediate finality approximately 22 hours a day with funds held at the Swiss National Bank (SNB). The SIC day begins at 18:00 CET with the transfer of the relevant SNB accounts to the respective SIC accounts. The day ends about 22 hours later in three steps. After the first cut off at 15:00 CET only covered payments can be submitted until cut off time 2 which is one hour later at 16:00 CET. After this time only payments submitted by the SNB are accepted for same day settlement. End of day processing starts at 16:15 CET until the next day begins at 18:00 CET. To support liquidity, especially with respect to the introduction of CLS, the SNB introduced an interest-free intra-day credit facility in form of intra-day repos in 1999. Intra-day credit may be drawn by SIC participants at the beginning of the SIC day at 18:00 CET or during the day upon request. In addition to the intra-day repos, mainly for short-term bridging, the banks are offered interest-bearing overnight money in the form of lombard loans. SIC is operated by Swiss Interbank Clearing AG which is a subsidiary of Telekurs Holding, a private sector company and is overseen by the SNB. CLS Bank holds an account with the SNB and is hence connected to SIC (BIS 2003*f*).

2.5.5 Australian Dollar and RITS

The Reserve Bank Information and Transfer System (RITS) is Australia's core RTGS system. It is operated and overseen by the Reserve Bank of Australia. Basic operating hours are between 07:30 Eastern Standard Time (EST) and 15:15 EST. As the CLS system requires overlapping opening hours of all participating RTGS systems, a three-hour extension of the RITS' opening hours had to be introduced. Including the extended hours of operation, RITS settles transactions from 07:30 EST to 18:00 EST. The Australian Dollar (AUD) is settled through respective entries in the so called Exchange Settlement (ES) accounts that the participants hold with the Reserve Bank.

RITS can be accessed either directly via a RITS terminal or by using one of the two feeder systems, the High Value Clearing System (HVCS) or Austraclear Limited's Financial Transaction Recording and Clearance System (FINTRACS). FINTRACS, a privately owned RTGS system, is mainly used for settlement of government and private sector debt securities. HVCS is a large value transfer system, based on a SWIFT service called Payment Delivery Service (PDS) (see 2.5.16) (Australian Payments Clearing Association 2004). It is especially built to handle foreign exchange transactions (BIS 1999). CLS Bank has an ES account with the Reserve Bank and is a member of the SWIFT PDS, through which CLS payments are transferred (Reserve Bank of Australia 2006).

2.5.6 Canadian Dollar and LVTS

Canada's two national payment systems are owned by the Canadian Payments Association (CPA), a non-profit organization. The Large Value Transfer System (LVTS) is the primary system for the unconditional transfer of large-value or time-sensitive Canadian Dollar (CAD) payments. It provides real-time processing and intra-day finality of payments as well as end-of-day settlement. LVTS differs from most other national large-value payments systems in that it is a real-time multilateral netting system and not an RTGS system (Roach 2003). Payments are categorized in tranche 1 and tranche 2 payments. Each tranche has its corresponding risk control mechanism to provide real-time risk control similar to an RTGS system. Tranche 1 payments are covered by collateral that the sending institution has pledged to the Bank of Canada for that reason. The sum of all tranche 1 payments sent by a particular participant cannot excess the value of the collateral. Tranche 2 payments are caped by a system of bilateral limits that are set at the beginning of each settlement day. Each participant has to deposit collateral with the Bank of Canada equal to the value of the largest bilateral credit line it has extended to any other participant. Because of collateral saving reasons the majority of payments are of type 2. The settlement cycle starts between 00:30 ET and 01:00 ET with the CLS participants setting their individual limit for tranche 1 payments as well as the bilateral limits for tranche 2 payments. From 01:00 ET to 07:00 ET CLS members send and receive payments to and from the CLS Bank through the Bank of Canada. After that, all other LVTS participants set their limits for tranche 1 and 2 and pledge the necessary collateral. Finally at 07:00 ET the LVTS opens for all other transactions. The settlement day ends at 18:30 ET when the two positions are merged and the final multilateral net positions are settled across settlement accounts at the Bank of Canada. Canada's second national payment system is the Automated Clearing Settlement System (ACSS) (BIS 2003*b*). In contrast to the real-time processing of LVTS, ACSS is a deferred net settlement system. It clears and settles all Canadian payments that are not handled by the LVTS. This includes for instance any paper-based payments (e.g. cheques), small-value electronic payments (e.g. debit card) or automated banking machine transactions (Bank of Canada 2006).

2.5.7 Danish Krone and KRONOS

In Denmark, large-value payments in Danish Krone (DKK) and Euro are processed via KRONOS, Danmarks Nationalbank's RTGS system. It is also the portal to TARGET, the EU central banks' real-time Euro gross payment system (see 2.5.2). To process CLS payments in Danish Krone, CLS Bank holds an account with Danmarks Nationalbank. KRONOS operates from 07:00 CET to 15:30 CET (Danmarks Nationalbank 2006).

2.5.8 Hong Kong Dollar and CHATS

The payment system for the Hong Kong Dollar (HKD) is named HKD Clearing House Automated Transfer System (CHATS). It is an RTGS system owned by the Hong Kong Monetary Authority (HKMA). All participants as well as CLS Bank hold an account with the HKMA through which the funds are settled. The system operates from 09:00 to 17:30 local time (BIS 2003*c*). Besides the HKD settlement system Hong Kong also operates RTGS systems for USD and Euro. They both use a similar technology as the HKD RTGS and allow participants to settle US Dollar and Euro transactions real-time in the Asian time-zone with the advantage of a PvP mechanism (Hong Kong Yearbook 2005).

2.5.9 Japanese Yen and BOJ-NET

There are two large-value settlement systems in Japan that settle the Japanese Yen (JPY). The Foreign Exchange Yen Clearing System (FXYCS) and the BOJ-NET Funds Transfer System. BOJ-NET is an RTGS system owned and operated by the Bank of Japan. FXYCS is a net system owned by the Tokyo Bankers Association but operated by the Bank of Japan and handles the clearing of foreign exchange transactions. Net positions resulting in FXYCS are transferred via BOJ-NET (Japanese Bankers Association 2003). With the introduction of CLS the Bank of Japan not also introduced an intra-day overdraft facility but also implemented a gross settlement option in FXYCS. CLS Bank is a participant of FXYCS since 2002. Common operating hours are from 09:00 to 17:00 local time and until 19:00 for participants that made an advance application the day before (BIS 2003*d*). Currently the Bank of Japan is working on a so called neXt-Generation RTGS project of the BOJ-NET. Among other features, the new system is planned to integrate the large-value payments that are currently still handled by FXYCS (Bank of Japan 2006).

2.5.10 Korean Won and BOK-Wire

The Bank of Korea (BOK) is running the Bank of Korea Financial Wire Network (BOK-Wire). It is the only large-value RTGS system that settles the Korean Won (KPW). It operates from 09:30 to 17:00 local time and until 18:30 if the transaction involves CLS. Any financial institution holding an account with the BOK is eligible to participate in the BOK-Wire. For CLS Bank to hold an account with the BOK and hence to become a participant in BOK-Wire, a legal amendment was necessary. Besides the transfer of the domestic currency, the system also offers transfers in US Dollar and Japanese Yen between foreign currency accounts held with the BOK. Participants may therefore transfer US Dollar and Japanese Yen to and from their central bank accounts to each other without using their correspondent bank (Bank of Korea 2006).

2.5.11 New Zealand Dollar and ESAS

The Exchange Settlement Account System (ESAS) is operated by the Reserve Bank of New Zealand. It is New Zealand's large-value RTGS system to settle the New Zealand Dollar (NZD). It provides settlement accounts for banks to settle their real time payments. ESAS accounts do not allow for overdrafts. To raise liquidity, participants need to have an intra-day repurchase agreement with the Reserve Bank. Liquidity is then provided during the ESAS day by a so called autorepo facility. An autorepo is generated as soon as the queued settlement requests hit the trigger amount that is specified by the participant. The ESAS day starts at 09:00 and ends at 08:30 the next day (Reserve Bank of New Zealand 2006).

2.5.12 Norwegian Krone and NBO

The Norwegian Krone (NOK) settles in Norges Bank's Settlement System (NBO). Funds are settled by debiting and crediting the corresponding bank accounts at the Norges Bank which provides intra-day liquidity against collateral. Settlement starts around 05:45 and ends at 16.30 CET (Norges

Bank 2006). A new technical platform is currently under construction. The new system, also an RTGS system, will be linked to a scandinavian cash pool to facilitate cross-currency liquidity among Norway, Sweden, and Denmark (CBR Online 2006).

2.5.13 Singapore Dollar and MEPS+

Large-value interbank transfers in Singapore are settled on a RTGS basis in the MAS Electronic Payment System (MEPS+). The system is operated by the Monetary Authority of Singapore (MAS) (BIS 2003*e*). MEPS+ is used to transfer same-day payments in Singapore Dollar (SGD) between banks. Payments are initiated by sending SWIFT messages. Provided that the paying bank has sufficient funds at its settlement account, the instruction will be settled instantaneously. To facilitate liquidity management the participants' reserve accounts at the MAS include a settlement sub-account. At 09:00 local time, when MEPS+ begins operation, funds are transferred from the reserve account to the settlement sub-account. Banks may also shift funds from the reserve account to that settlement account during the day. The system closes at 18:30 local time when all funds are transferred back to to the reserve account (Monetary Authority of Singapore 2006).

2.5.14 South African Rand and SAMOS

The Real-Time Gross Settlement service provided by the Reserve Bank of South Africa is called the South African Multiple Option Settlement (SAMOS) system. The system not only settles large-value transactions in Rand (ZAR) between banks but also retail payments and obligations arising from equity and bond markets. Large-value transactions, including CLS transactions, are settled from midnight until 17:00 CET. During the evening hours from 17:00 CET until midnight, only retail transactions are processed. CLS Bank holds an account with the South African Reserve Bank (South African Reserve Bank 2006).

2.5.15 Swedish Krona and RIX

The central bank of Sweden, Sveriges Riksbank, operates a national RTGS system named RIX. It settles large-value transfers and customer payments in Swedish Krona (SEK) and until the end of 2006 also offered a parallel settlement system for Euros that is connected to TARGET (see 2.5.2). Currently a new technical platform for RIX is under construction. The new system will no longer be connected to TARGET. For settlement each bank holds either directly a RIX account with the Riksbank or settles indirectly via an intermediary, called a clearing bank. CLS Bank is a direct participant of the system. Settlement hours for Swedish Krona are between 07:00 CET and 17:00 CET (Sveriges Riksbank 2006).

Table 2.1 provides an overview of the RTGS systems' for those currencies that are included in the CLS system. As they are part of the CLS system they must have overlapping opening hours. The table shows the systems' opening hours in CET as well as the corresponding local time and if applicable, includes extended opening hours to settle CLS transactions[1].

Country	**Currency**	**System**	**CET Hours**	**Local Time**
USA	USD	Fedwire	06:30 - 00:30	00:30 - 18:30
EU	EUR	TARGET	07:00 - 18:00	07:00 - 18:00
UK	GBP	CHAPS	07:00 - 17:20	06:00 - 16:20
Switzerland	CHF	SIC	18:00 - 16:00	18:00 - 16:00
Australia	AUD	RITS	23:30 - 10:00	07:30 - 18:00
Canada	CAD	LVTS	07:00 - 00:30	01:00 - 18:30
Denmark	DKK	KRONOS	07:00 - 15:30	07:00 - 15:30
Hong Kong	HKD	CHATS	02:00 - 10:30	09:00 - 17:30
Japan	JPY	BOJ-NET	01:00 - 11:00	09:00 - 19:00
Korea	KPW	BOK-Wire	01:30 - 10:30	09:30 - 18:30
New Zealand	NZD	ESAS	22:00 - 21:30	09:00 - 08:30
Norway	NOK	NBO	05:45 - 16:30	05:45 - 16:30
Singapore	SGD	MEPS+	02:00 - 12:30	09:00 - 18:30
South Africa	ZAR	SAMOS	23:00 - 16:00	00:00 - 17:00
Sweden	SEK	RIX	07:00 - 17:00	07:00 - 17:00

Table 2.1: Opening Hours of RTGS systems.

2.5.16 SWIFT

The Society for Worldwide Interbank Financial Telecommunication (SWIFT) is not a payment system but an industry-owned service provider who sup-

[1] Time conversions are based on winter times.

plies standardized messaging services. It was formed in 1973 to facilitate communication among banks and to replace the large post mail and fax traffic (Riedl 2002). Today almost 8'000 financial institutions in more than 200 countries are SWIFT members and use SWIFT messages to send and receive instructions or confirmations regarding different kinds of financial transactions (SWIFT 2006). The messages are transferred on a secure IP network in standardized formats called Message Type (MT). To each different financial transaction a number is assigned, such as the MT300 for foreign exchange transactions. SWIFTNet FIN is SWIFT's core messaging service. It is an interactive communication service providing a request and response message exchange for these MT-messages among the connected institutions. The SWIFTNet FINCopy service is a value-adding feature of SWIFTNet FIN and can be used to automatically send a copy of the original message to a third party, for instance the settlement institution. Besides this, SWIFT offers a whole range of other services such as SWIFTNet Accord, a matching machine, or SWIFTNet CLS Third Party Service, a service package for non-CLS members that use CLS services.[2]

2.6 Chapter Summary

Settlement is the process of discharging buyer and seller of financial contracts from their obligations by transferring the corresponding funds and securities. In case of foreign exchange contracts only funds are transferred and the transaction is said to have two cash legs. There are four operational features inherent to RTGS as well as netting systems that are of special interest:

- **Settlement finality** guarantees that at some point during the settlement process, the transfer of payments is unconditional and irrevocable under any circumstances.

- **Payment versus payment** settlement standards eliminate credit risk by transferring funds simultaneously and only if both counter-payments are accomplished.

- **Provision of performance guarantee** is offered by a clearing or settlement institution that substitutes itself as a buyer to the seller and as a seller to the buyer. Such an institution is generally called a central counterparty (CCP).

[2]For further details on SWIFT products and services refer to www.swift.com.

- **Settlement risk** occurs from the time of the trade until the final transfer of funds and can be split in three different risk types: liquidity risk, credit risk, and market risk.

While RTGS systems settle transactions sequentially on a gross and continuous basis, netting systems only settle net amounts at specific times during the business day. The crucial element that relates RTGS and netting systems is the duration of the settlement delay. It can be shown that an RTGS system queuing all transactions and settling them at the end of the business day, requires the same amount of liquidity from its participants as a multilateral netting system. As RTGS systems are considered to be more stable in terms of systemic stability, most large-value transfer systems today are based on RTGS rules. The main issue regarding the settlement of foreign exchange contracts is the geographical distance between the counterparties. They settle transactions in different domestic payment systems that are possibly located in different time zones. Several potential solutions had been proposed to reduce or eliminate settlement risk despite these difficulties. The most obvious is to extend the opening hours of the relevant payment systems to enable a PvP mechanism. This indeed was the prerequisite for the construction of the CLS system. Section 2.5 introduces the settlement systems that are relevant in the context of CLS. They are mostly operated on a RTGS basis and show overlapping opening hours.

Chapter 3

CLS Environment

This chapter introduces the foreign exchange market environment which represents the background for the development of the CLS system. The chapter is focused on three aspects that are considered to be the main drivers for the development of CLS: (1) the absence of a foreign exchange settlement system able to reduce settlement risks at that time, (2) several near collapses of the systems due to failing market participants, and (3) the recommendations of the Bank for International Settlements. The chapter starts off with an overview of the foreign exchange market and its products. It introduces the difficulties of foreign exchange settlement and shows the implications regarding settlement risks. With this background the following sections describe the key settlement incidents which evoked serious concerns of central banks and the Bank for International Settlements regarding settlement risks in foreign exchange transactions. It provides a summary of the events and relates them to actions taken by central banks. The third part summarizes the relevant publications of the Bank for International Settlements. It identifies the important steps that finally led to the initiative of the G20 to build the CLS system. The chapter summary provides a chronological overview.

3.1 The Foreign Exchange Market

The foreign exchange market is the largest market in the world and still shows increasing volumes. For the year 2007 an average daily turnover of USD 3.2 trillion[1] is estimated. Measured at constant exchange rates, this is an increase of 65 percent compared to the year 2004 (BIS 2007). To relate this figure to other markets, the average daily trading volume of the

[1]To compare this figure to other markets, only one leg of the transaction is counted and not the sum of both legs that are to be settled.

world's second largest market, the U.S. Treasury securities market, amounts to about USD 500 billion (Federal Reserve Bank of New York 2004). The foreign exchange market is more than six times larger in turnover volumes than the second largest market in the world.

3.1.1 Foreign Exchange Products

The foreign exchange market can be broken down into three traditional over-the-counter (OTC) segments: spot transactions, outright forwards, and foreign exchange swaps. Prior to 1970 these were the only products traded. Today they still account for the major share of total foreign exchange market activity. A spot transaction involves a straightforward exchange of two currencies within two business days. This two day period provides time for matching and arranging settlement. Trades for value dates in advance of the spot value date are also possible (so called pre-spot or ante-spot transactions). Such transactions, however, only account for a small part of the market, particularly same day cash transactions involving countries in different time zones (Cross 1998). For spot transactions, like for outright forwards the exchange rate is fixed at the day of the contract closure. The only difference between spot transactions and outright forward contracts is the value date. While spot transactions settle no later than two business days after the deal date, outright forwards are settled at any pre-agreed date, three or more business days after the deal date. The term outright forward is used to emphasize that it is a single purchase and not part of a foreign exchange swap. Foreign exchange swaps consist of two transactions which settle at two different value dates. The near transaction includes the exchange of two currencies on a specific date while the long transaction represents a reverse exchange of the same two currencies at a later date. The exchange rates for the legs usually differ from each other and are set at the day of the contract closure. The foreign exchange swap can also be reproduced by a spot transaction and an outright forward going in opposite directions. Table 3.1 shows the development of the average daily turnovers in these segments. Besides the traditional segments, there are three other products which trade OTC: currency swaps, currency options, and non-deliverable forwards (NDF). Currency swaps differ from foreign exchange swaps in that it is not only one exchange and a respective re-exchange but a stream of payments. In a currency swap transaction counterparties exchange and re-exchange principal and streams of fixed or floating interest payments in two different currencies. Mostly, the two parties at first exchange equal initial principal amounts of two currencies at the spot rate and subsequently exchange a stream of fixed or floating interest rate payments for an agreed period of time. At the end

Year	1995	1998	2001	2004	2007
Spot transactions	494	568	387	621	1'005
Outright forwards	97	128	131	208	362
Foreign exchange swaps	546	734	656	944	1'714
Estimated gaps in reporting	53	60	26	107	129
Total traditional turnover	**1'190**	**1'490**	**1'200**	**1'880**	**3'210**

Daily transaction averages in April, in billions of USD. Figures are adjusted for local and cross-border double-counting.

Table 3.1: Global Foreign Exchange Market Turnover (BIS 2007).

of this period the principal amount is re-exchanged at the initial spot rate (Cross 1998). Currency options are rights to buy or sell a specified amount of one currency for another at a specified price on a specified date. In contrast to forwards and futures it is an option and not an obligation to execute. Certain currency options as well as currency futures are exchange traded. NDFs are foreign exchange derivative products. An NDF contract settles not by delivering the underlying pair of currencies, but by making a net payment typically in US dollar. The net payment is equal to the difference between the agreed forward exchange rate and the actually realized spot fixing (Guonan, Ho & McCauley 2004).

3.1.2 Currency Composition

The US dollar is the world's most traded currency. In 2001 the dollar was on one side in about 90 percent of all transactions. For the year 2007, the US dollar share is estimated to be around 86 percent. It is followed by the Euro being on one side in 37 percent of all contracts. Table 3.2 shows the percentage shares of the most traded currencies. Dollar/Euro transactions account for 27 percent of global turnover which makes it the most traded currency pair (BIS 2007). Table 3.3 provides an oversight of the percentage turnover of the relevant currency pairs.

3.1.3 Settlement of Foreign Exchange Transactions

To actually settle the foreign exchange contracts it is important to understand the anatomy of the transaction in detail. Each foreign exchange transaction consists of two separate legs, each referring to one of the two involved currencies and the two contract partners respectively. For one of the legs, one

Year	**2001**	**2004**	**2007**
US dollar	90.3	88.7	86.3
Euro	37.6	37.2	37.0
Japanese yen	22.7	20.3	16.5
Pound sterling	13.2	16.9	15.0
Swiss franc	6.1	6.1	6.8
Australian dollar	4.2	5.5	6.7
Canadian dollar	4.5	4.3	4.2
Swedish krona	2.6	2.3	2.8
Hong Kong dollar	2.3	1.9	2.8
Norwegian krone	1.5	1.4	2.2
Korean won	0.8	1.2	1.1
Mexican peso	0.9	1.1	1.3
New Zealand dollar	0.6	1.0	1.9
Singapore dollar	1.1	1.0	1.2
Other currencies	11.6	11.2	14.2
All currencies	200	200	200

Percentage shares of average daily turnover in April. Because two currencies are involved in each transaction, the sum of the percentage shares totals 200 percent.

Table 3.2: Currency Distribution (BIS 2007).

contract partner is the buyer and the other the seller, for the second leg the roles of the contract partners are allocated vice versa. Figure 3.1 visualizes this relation. Each contract partner is the buyer of one particular currency and the seller of the other currency respectively. To settle the contract, the two legs of the transaction are processed separately via the respective local large-value transfer systems (LVTS). In most countries the LVTSs settle in RTGS mode. However, the time lags between the countries of the currencies' origins sometimes makes it impossible for the two legs to settle at the same time (see chapter 2). When one party has released the payment of its owed amounts it does not know if or when the counterparty has released or will release the counter-payment. It might then take up to three business days until the party that has transferred the owed funds, receives final confirmation regarding the receipt of the counter-payment (CPSS 1996). This time lag between the payment and the final confirmation regarding the receipt of the counter-payment is the primary source for the emerging risks during settlement.

Year	2001	2004	2007
US dollar/Euro	30	28	27
US dollar/Yen	20	17	13
US dollar/Sterling	11	14	12
US dollar/Swiss franc	5	4	5
US/Canadian dollar	4	4	4
US/Australian dollar	4	5	6
US dollar/other	17	16	17
Euro/Yen	3	3	2
Euro/sterling	2	2	2
Euro/Swiss franc	1	1	2
Euro/other	2	2	4
Other currency pairs	2	2	4
All currency pairs	100	100	100

Percentage shares of average daily turnover in April. Figures are adjusted for local and cross-border double-counting.

Table 3.3: Market Turnover by Currency Pair (BIS 2007).

3.1.4 Emerging Risks During Settlement

Due to the characteristics of a foreign exchange contract, three main risks emerge during settlement: market risk, credit risk, and liquidity risk. In the following, the duration of a successful settlement shall be defined as the time span between the conclusion of the contract and the final and irrevocable receipt of the payments of both contract partners. During this time the following risks may occur (Geiger & Spremann 1998):

- **Market risk:** each party is exposed to market risk during the time of the conclusion of the contract up to the irrevocable release of each party's payment. In case one party fails in this phase of the settlement the counterparty would have to replace the contract possibly delayed and at higher costs.

- **Credit risk:** after the irrevocable release of one party's payment, this party is exposed to credit risk which amounts to the full value of the contract. The exposure lasts until this party gets acknowledged receipt of the owing funds. This might take up to three business days. If the counterparty fails during this phase, the face value of the contract is

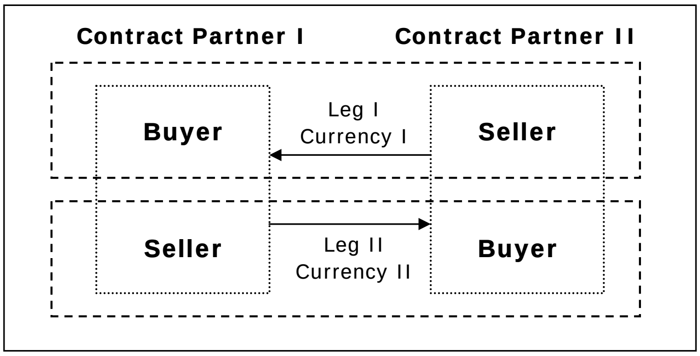

Figure 3.1: Characteristic of a Foreign Exchange Contract (author).

lost. Due to the high face values of foreign exchange contracts, the amounts at risk can be tremendous and might even excess the party's equity (CPSS 1996). However, as the probability of a counterparty braking down exactly during this relatively short period of time is extremely low, a common risk measurement based on probability and value at risk does not provide a sensible estimation of the risks assumed. Due to the exposure dimensions, credit risk is the main driver for the concerns regarding foreign exchange settlement.

- **Liquidity risk:** in case the counter-payment is delayed, liquidity risk occurs because the other party has expected to receive the owing funds on time. As a consequence it might not be able to meet its existing payment obligations due to the delay of the incoming funds. Prevalently it is operational risk such as technical disruptions that give rise to liquidity risk.

Figure 3.2 schematically illustrates these different risk phases. In reality, the three risk phases do not exactly replace each other but overlap. An alternative illustration of the different settlement phases can be found in section 3.3.4.

3.2 Causes for Central Bank Concerns

During the last 30 years there have been real losses and near misses highlighting the significance of the risks described in the previous section. These incidents rose central banks' concerns and stressed the importance of international cooperation to reduce these risks. The following section provides a brief summary of the most drastic incidents.

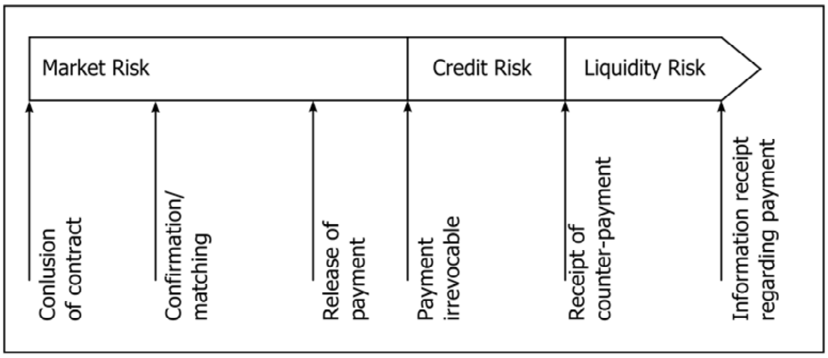

Figure 3.2: Settlement Risk Phases (Geiger & Spremann 1998).

3.2.1 Collapse of Bankhaus Herstatt

The year 1974 was the starting point of the growing awareness concerning settlement risk in foreign exchange transactions. In that year, on June 26 at 15.30 CET, after the end of the local banking day, the German authorities closed down Bankhaus Herstatt. It was a small German bank in Cologne which was very active in foreign exchange markets. In those days the bank was known for taking on foreign exchange positions that were much larger than its capital. Young traders were speculating on an increase of the US dollar. A sharp increase in oil prices, however, caused the US dollar to fall. German authorities discovered fraudulently concealed losses in Bankhaus Herstatt's books and subsequently withdrew their banking license. All banking activities were immediately shut down. In the US, the business day had just started and at least twelve US counterparties of Bankhaus Herstatt had irrevocably transferred large amounts of Deutsche Mark (total estimated amount is USD 200 million) to the defaulting bank. Due to the time lag they did not receive their outstanding US dollar payments, thus, faced an exposure of the full amount of their Deutsche Mark payments made (credit risk and liquidity risk). Moreover, all banks having entered into forward trades with Bankhaus Herstatt had to replace the contracts in the market (market risk). The failure caused a chain reaction as other banks refused to make their payments and closed their credit lines for banks that were suspected to be counterparties of Bankhaus Herstatt. As it was unknown which banks had suffered losses, most banks were unwilling to meet their obligations unless they received confirmation that the counter-payment had been received. The USD/DM market was immediately disrupted. The multilateral net settlement system in New York nearly collapsed and the recovery took several business days (Dale (1984) and Remolona (1990)). Bankhaus Herstatt was the first and most severe case in a series of incidents over the following years. It was the first time that settlement risk in foreign exchange trading had attracted major public attention.

3.2.2 Drexel Burnham Lambert Group

In March 1989 Drexel Burnham Lambert Group (DBLG), at that time one of the most profitable investment banks on Wall Street, pleaded guilty to six felony charges and agreed to pay USD 650 million in fines (Breeden 1990). For the year 1989 the group reported consolidated assets of USD 28 billion and USD 836 million of equity. Regardless of the conviction of DBLG its broker subsidiary Drexel Burnham Lambert (DBL) still had a strong capital basis and continued its business. As a registered broker DBL was regulated by the Securities Exchange Commission (SEC). Another subsidiary, Drexel Burnham Lambert Government Securities Inc. (GSI) stayed a primary dealer with whom the FED kept on conducting open market operations. The financial soundness of primary dealers is closely monitored by the FED to assure their reliability as market makers for government securities. Thus, two of DBLG's subsidiaries were operating under federal supervision. However, the holding company DBLG itself was not subject to federal oversight but to functional regulation. This means that the different roles of DBLG (as a broker and a primary securities dealer) were subject to separate regulation and supervision. Instead of supervising the soundness of DBLG as an institution itself, the subset of DBLG's functions were separately regulated (Franklin & Herring 2001). DBLG was a key player in the secondary market for low-grade bonds. During 1989 a series of events dramatically depleted the liquidity in this market. First, confidence in DBLG was undermined by its guilty plea and another indictment on racketeering and securities fraud. Second, in summer of 1989 the US Congress ruled that certain thrift institutions must sell their holdings in low-grade bonds. Third, newly developed covenants supposed to protect investors against abrupt declines in credit quality did not prove effective. The Campeau Group's default in September 1989 further decreased market liquidity in low-grade bonds. The financial structure of DBLG was violently damaged. In December of the same year Standard and Poor's (S&P) downgraded DBLG's commercial paper and reduced its rating even further to speculative on February 12 in 1990. Unable to issue any new commercial papers and without the assistance of the authorities DBLG was forced to file for protection under Chapter 11 of the bankruptcy laws[2].

[2]Chapter 11 allows a defaulting company to temporarily continue operations under the protection and supervision of the Bankruptcy Court.

The market, however, did not distinguish the holding company filing Chapter 11 and the solvent, regulated subsidiaries. DBLG's sound subsidiaries got blocked in a gridlock situation. Afraid of credit exposures during settlement, counterparties stopped business also with the solvent subsidiaries of DBLG. Simultaneously, the healthy subsidiaries of Drexel Burnham retained their payment orders as they were concerned that the counterparty might use the payment to set-off against liabilities due from other DBLG companies. The Bank of England as well as the Federal Reserve Bank of New York had to intervene and assured the market participants that transactions with the solvent subsidiaries of DBLG and the administrator trustee of the holding company would be completed. The Bank of England set up an ad hoc settlement facility for one of DBLG's healthy subsidiaries, Drexel Burnham Lambert Trading (DBLT). In that, the Bank of England acted as an intermediary between DBLT and its counterparties. Instead of paying directly to DBLT accounts at the correspondent bank, the counterparties transferred the amounts due to an account held in the name of the Bank of England at the correspondent bank. As soon as the receipt of funds was confirmed by the Bank of England, DBLT irrevocably released the counter payment. In turn, when a particular counterparty received the payments from DBLT, it authorized the Bank of England to transfer the deposits to DBLT's accounts. This settlement mechanism turned out to be efficient and was kept in place for a whole week. However, several factors were prerequisite to make this a viable and efficient solution: the subsidiary DBLT was solvent and willing to settle all trades, the management and traders of DBLT stayed in place what significantly supported the unwinding process, and the Bank of England was accepted as a neutral facilitator by all parties involved. The absence of one of these factors would have complicated and delayed the unwinding of the gridlock.

3.2.3 Bank for Credit and Commerce International

The Bank for Credit and Commerce International (BCCI) was closed on July 5 in 1991. BCCI had built up a complex corporate structure which made it virtually impossible for supervisory authorities to monitor the activities of BCCI on a consolidated basis. In 1991 the US Shadow Financial Regulatory Committee stated, "BCCI's headquarters were established in countries with weak supervisory authorities, strong secrecy laws and neither lenders of last resort nor deposit insurers who would have financial reasons to be concerned about the solvency of banks that are chartered in their jurisdictions" (SFRC 1991). None of the relevant national bank supervisors had the authority to compel BCCI to reorganize its corporate structure so that it could be monitored on a consolidated basis. In April 1990, Price Waterhouse which at that time had become the sole auditor of BCCI reported to the Bank of England large scale fraud in a number of business activities. The auditors of Price Waterhouse did not give an opinion on the 1990 accounts and indicated that they were not even sure whether it was going concern. Price Waterhouse was assigned by the Bank of England to further investigate on the issue. On June 24 in 1991, a detailed report was delivered documenting the massive fraud. At mid day on July 5, the Bank of England applied to the UK court for appointment of a provisional liquidator. The procedure was carefully planned and the relevant authorities in each country took parallel action to minimize the damage to creditors. However, BCCI had sent a payment instruction message to its New York correspondent one day prior to the close-down to make a US dollar transfer for value on July 5. Due to a credit limit placed on BCCI's correspondent the payment remained in the queue. Having not yet settled the BCCI transaction the correspondent received a message from BCCI's provisional liquidator in London and canceled the payment. BCCI's counterparty in that way lost the principal amount of the contract. Other principal losses occurred for Japanese banks due to the time lag. As Yen had been paid to BCCI SA Tokyo on that particular day and BCCI's assets in New York had already been blocked prior to the settlement of the US dollar leg, the banks lost the full values exposed. For an extensive discussion of BCCI, refer to Herring (1993). The BCCI affair illustrates the difficulties arising from a shutdown of banks that are active in the foreign exchange market. Today, regulators agree that to minimize damage, an internationally operating bank must be closed down on Friday night after the closing of the US business day.

3.2.4 Attempted Soviet Coup D'État

The attempted coup d'état in Moscow in mid August 1991 caused a disruption in settlement over several days. When members of the Politburo and the leaders of the Soviet military and security services detained Gorbachev in the evening of August 18, the international community considered it as a serious political crisis. Most counterparties of the Russian institutions active in foreign exchange markets were not willing to expose themselves to the risk that due to the adverse political situation their contracts will not be fulfilled. Instead they claimed collateral or acceptable third party guarantees in advance of releasing the funds. As a result, settlement was delayed. In some cases the Russian institutions' correspondents were even unwilling to release funds despite the received collateral. Instead of paying out funds due on a particular day, they kept them back to cover amounts that were due to receive from that same customer on the following day. Correspondents intended to protect the western counterparties from principal risk. In that, they exposed the Russian institutions to serious liquidity risks in a time when money markets were increasingly unwilling to enter deals with them. Partly with the support of public authorities and bilateral agreements between institutions a global collapse of the payments system could fortunately be avoided. For more details on this incident see CPSS (1996). The crisis demonstrates how settlement risks can arise from unstable political environments.

3.2.5 Barings Crisis

In February 1995 Barings PLC, the oldest merchant bank in London at that time, collapsed. Similar to BCCI, Barings was characterized by a complex international corporate structure. Unlike BCCI which collapsed because of massive fraud, Barings was disrupted by the fraud committed by a single trader, Nick Leeson. Being a chief trader he was also responsible for settling his trades. This was a clear failure of internal controls. It enabled him to use an error account to hide his losses. Already in December 1994 the loss on this account amounted to more than USD 500 million without being noticed by Leeson's supervisors (BBC 2005). Trying to cover his losses, Leeson speculated on an increase of the Nikkei index. On January 17 in 1995, a disastrous earthquake hit the Japanese city of Kobe. The Nikkei index dropped by 7 percent within a week. In a desperate attempt to move the market Leeson took on even more uncovered bets. On Friday, February 24 in 1995 Barings had to report to the Bank of England that it would not be able to meet its margin calls for the following Monday. Over the weekend the Bank of England was trying to find a solution to avert a final break down. No financial institution was willing to support Barings as the extent of losses was unidentified. Without any hope of recovery, Barings turned to the bankruptcy court on Sunday evening, February 26. Besides many other adverse issues resulting from the closing of Barings it almost caused a substantial settlement problem on that day. A clearing bank had sent a payment instruction to Barings' correspondent on Friday 24, for value on Monday. Immediately after the close-down of Barings the correspondent tried to cancel the instruction. The clearing process did not permit cancelation nor was the receiving bank able to reverse the transaction. The sending bank ended up with a net debit position in clearing that day. To enable settlement, the bank agreed to borrow the amount from another bank. Without a quick decision to do so, settlement for that day, involving 45 banks, would have been frustrated and the clearing would have had to be unwound even though less than one percent of the payments had anything to do with Barings (CPSS 1996). For a detailed discussion of the Barings crisis refer to Herring (2003). The Barings crisis as well as the other incidents described, demonstrates the importance of clearing participants having a thorough understanding of the rules and processes of their clearing system. Even a failure of small transactions may trigger spill-over effects that can easily initiate serious disruptions in a clearing system. In case of an institution's break down the timing of the closing might be very important to avoid systemic disruptions. Central banks' risk perception with regard to international settlement was continuously growing due to these incidents. As a result, the Bank for International Settlements formed committees such as the Group of Experts on Payment Systems and the Committee on Interbank Netting Schemes to monitor these issues and to provide future guidance and recommendations. In 1990, these committees were replaced by the Committee on Payment and Settlement Systems.

3.3 Reports of the CPSS

The Committee on Payment and Settlement Systems (CPSS) was established in 1990 under the auspices of the Bank for International Settlements (BIS). The committee took over and extended the work of the Group of Experts on Payment Systems and the Committee on Interbank Netting Schemes. Today, CPSS is one of the permanent Group of Ten countries (G10) central bank committees reporting to the G10 governors. It serves as a forum to monitor and analyze developments in domestic payment settlement as well as in cross-border and multi-currency settlement systems (CPSS 2005). The reports published by the CPSS provided the main guidance regarding the development of new settlement standards for foreign exchange transactions and played a key role in the development of the CLS system. This section provides a summarizing overview of the relevant CPSS reports.

3.3.1 Angell-Report

In 1989 a detailed study on various kinds of internationally related financial netting arrangements was initiated. The G10 central banks were interested in how far existing or future netting arrangement might contribute to the efficiency of the international payment systems, and what effect they may have on credit and liquidity risk. The outcome of the study is described in the "Report on Netting Schemes" (BIS 1989), the so called Angell-Report, named after the chairman of the Group of Experts on Payment Systems, Wayne D. Angell. It finds that banks have strong incentives to lower their credit exposure as well as interbank payment flows mainly due to transaction costs and implicit or explicit costs of holding balances and obtaining credit to effect settlement. This leads to innovations based on interbank netting solutions. The report highlights the importance of balancing the efficiencies of netting solutions against the costs associated with the credit and liquidity risks that come along. It provides guidance for banks assessing operations and associated risks concerning their current or future netting arrangement.

3.3.2 Lamfalussy-Report

Immediately after the Angell-Report was published, the G10 governors set up an ad hoc Committee on Interbank Netting Schemes to further analyze the policy implications of cross-border and multi-currency netting arrangements described in the Angell-Report. The Committee prepared in 1990 the "Report of the Committee on Interbank Netting Schemes of the Central Banks of the Group of Ten countries" (CPSS 1990) or the Lamfalussy-Report, named after the chairman of the committee, Alexandre Lamfalussy. The report concludes that netting can reduce the size of credit and liquidity exposures and thereby contributes to the limitation of systemic risk. Yet it also notes that even when actual exposures are reduced, multilateral netting systems can shift and concentrate risks in ways that might increase systemic risk by increasing the likelihood that one party's failure will undermine the stability of others. The analysis suggests a centralized, collateral-based approach to be most efficient with respect to systemic risk. The collateral, however, comes at a cost. To avoid the cost, the report looks at a purely decentralized approach and finds that it would maintain incentives for the participants to manage their own exposures but at a lower level of over all settlement assurance. The principal concern for monetary policy that is identified by the report, results from the possibility of inadequate risk management procedures of netting participants. Based on the analysis the committee concludes that there is a need for collective policy responses concerning the design and operation of netting schemes, the management of credit and liquidity risk, as well as effective central bank oversight. The committee takes a step forward and agrees upon minimum standards for the design and operation of cross-border and multi-currency netting schemes. These minimum standards are known as the Lamfalussy-criteria and are summarized in the following (for supporting explanations see part C of the report):

1. Netting schemes should have a well-founded legal basis under all relevant jurisdictions.

2. Netting scheme participants should have a clear understanding of the

impact of the particular scheme on each of the financial risks affected by the netting process.

3. Multilateral netting systems should have clearly defined procedures for the management of credit risks and liquidity risks which specify the respective responsibilities of the netting provider and the participants. These procedures should also ensure that all parties have both, the incentives and the capabilities to manage and contain each of the risks they bear and that limits are placed on the maximum level of credit exposure that can be produced by each participant.

4. Multilateral netting systems should, at a minimum, be capable of ensuring the timely completion of daily settlements in the event of an inability to settle by the participant with the largest single net-debit position.

5. Multilateral netting systems should have objective and publicly-disclosed criteria for admission, which permit fair and open access.

6. All netting schemes should ensure the operational reliability of technical systems and the availability of back-up facilities capable of completing daily processing requirements.

The committee stressed that these criteria are not a statement of best practice but only minimum standards which should be met by all netting schemes. In addition the committee worked out core principles for co-operative central bank oversight of netting systems. It argued that for cross-border and multi-currency systems, a similar oversight function as for domestic markets is necessary. The committee suggested that central banks should respond to this issue in accordance with the principles set forth. The minimum standards for netting systems and the principles for co-operative central bank oversight set the baseline for further developments in cross-border and multi-currency netting systems. With the publication of the report, the G10 central bank governors called on the Committee of Payment and Settlement Systems to "continue to review possible measures that central banks might take - either individually or on a cooperative basis - to improve efficiency and reduce risks in the settlement of cross-border and multi-currency transactions" (CPSS 1990).

3.3.3 Noël-Report

Three years later, in 1993 the Committee on Payment and Settlement Systems responded to the call of the G10 central bank governors and prepared an analysis to identify and enhance a common understanding of the advantages and disadvantages of different central bank services related to payment and settlement systems. The committee published its work in the report "Central Bank Payment and Settlement Services with Respect to Cross-Border and Multi-Currency Transactions" (CPSS 1993). Named after Tim Noël, chairman of the working group, the analysis is also called Noël-Report. The report looks at four different payment services which currently were or could have been offered by central banks: (1) local currency payment and settlement services, (2) extended operating hours of local currency payment systems, (3) cross-border links between payment systems, and (4) multi-currency payment and settlement services. It established a framework to assess these services with respect to central bank policy concerns. It thereby considered the substantial differences in legal, institutional, and monetary policy perspectives of the G10 countries' central banks. In detail, the report applies the following policy issues to the different service options:

1. Monetary policy implementation: the ability of central banks to adequately control and forecast supply and demand of reserve balances as well as open market operations and central bank lending might affect interests and exchange rates.

2. Private sector source of liquidity: for a new service the necessary degree of liquidity in each currency to support settlement is influenced by the availability of a particular currency during settlement, the amount of final transfers into settlement accounts, and possible collateral.

3. Systemic risk: the impact of a new service on systemic risk depends on the incentives for participants to reduce credit and liquidity risk and on the degree of reliance on public and private sector credit and liquidity.

4. Well founded legal basis: there are differences in each country depending on the legal status of settlements.

5. Competitive effects: depending on which private financial markets are served and which entities would benefit from the new service, correspondent banking relationships are likely to change.

6. Cost effectiveness: from a participant's perspective costs include the initial investment as well as ongoing operating charges and the cost of idle balances compared to the current service.

7. Acceptability of the service from an individual central bank perspective: whether a new service is acceptable for a particular central bank

depends on the amount of the initial investment, the implementation timetable, later operating costs, necessary legal and policy changes, the implications for supervision, and the implications for the central bank as liquidity provider.

Analyzing the different central bank settlement services under these aspects clearly showed that each central bank will view the issues from a different perspective determined by individual circumstances of each central bank. Thus, the Noël-Report did not recommend a single preferred service option. Central banks from different countries individually weigh the impacts of the various services on the defined policy issues. Each of the service options shows potentially significant advantages and disadvantages for each central bank. In summary, the report highlighted the interrelation of domestic settlement system features with international settlement arrangements and pointed out the need for private sector efforts to reduce risks and advance efficiency of cross-border and multi-currency settlement.

3.3.4 Allsopp-Report

In 1996, three years after the Noël-Report, the Committee on Payment and Settlement Systems formed a steering group to work on a practical approach to dealing with settlement risk in foreign exchange transactions. The report "Settlement Risk in Foreign Exchange Transactions" (CPSS 1996), also called Allsopp-Report, named after the working group's chairman Peter Allsopp, summarizes their findings. This report is the first that extensively describes the past incidents such as the failure of Bankhaus Herstatt or Drexel Burnham Lambert (see 3.2). It furthermore identifies the different types of risks involved in foreign exchange settlement. The report for the first time provides a well defined measure to quantify foreign exchange settlement exposure. Based on a practitioner's view it describes foreign exchange settlement exposure as "a bank's actual exposure - the amount at risk - when settling a foreign exchange trade equals the full amount of the currency purchased and lasts from the time a payment instruction for the currency sold can no longer be cancelled unilaterally until the time the currency purchased is received with finality" (CPSS 1996). It is noted that in order to apply this definition to properly measure the size and duration of an exposure, a bank must be able to identify for each trade its current settlement status. The report divides the settlement process in the following five categories:

1. Status R = Revocable. Payment instructions have not yet been issued or may unilaterally be cancelled. There is no settlement exposure at this stage.

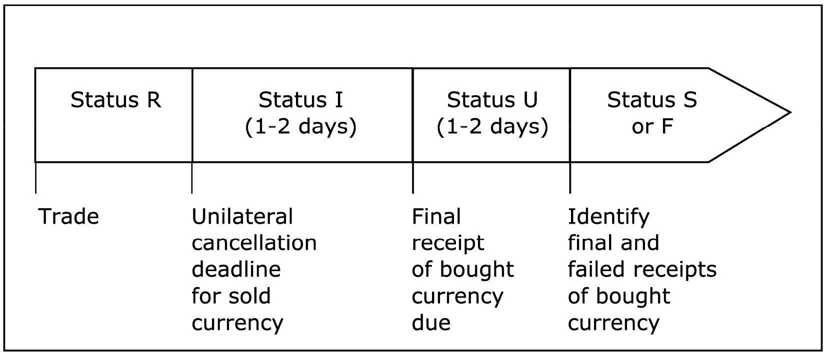

Figure 3.3: Changing Status of a Trade (CPSS 1996).

2. Status I = Irrevocable. Unilateral cancellation is not possible anymore but the final receipt of the counter currency is not yet due. The amount that is bought is currently exposed.

3. Status U = Uncertain. Receipt of the bought currency is due but in fact the bank does not know whether it has received the funds with finality. The amount might thus still be at risk.

4. Status F = Fail. The bank has not received the funds. The amount stays exposed.

5. Status S = Settled. The funds are transferred with finality. The trade is considered settled and the funds no longer at risk.

Figure 3.3 illustrates the settlement process based on these five steps. To measure its exposure a bank should know at least two critical points in time: (1) the unilateral cancellation deadline and (2) identification of final and failed receipts. The maximum exposure for this particular bank amounts to the sum of trades in status I, U, and F. It equals the amount of bought currencies that can no longer unilaterally be stopped but have not been received and the amount that should, but might not, have been received:

$$Exposure_{max} = I + U + F \tag{3.1}$$

If a bank is able to identify whether the amounts due have actually been received its minimum exposure results in:

$$Exposure_{min} = I + F \tag{3.2}$$

Hence, banks that identify their final and failed receipts of funds as soon as they come due exactly know their exposure at any point in time. Having set the definitions, the steering group conducted a survey including 80 banks in the G10 countries to analyze current practices in foreign exchange settlement. The survey led to the conclusion that it usually takes more than three business days from the point when payment instructions are irrevocable (status I) until the bank knows with certainty that it has received the funds due (status S). Thus, settlement exposures often last for more than three business days. Due to the fact that most banks did not measure their exposures, the report does not provide comprehensive statistics on the amounts exposed. However, the survey indicates that a bank's exposures could even exceed its capital. Based on the survey the steering group believed that the private sector institutions have the potential to significantly reduce settlement risk in foreign exchange transactions. A three-track strategy was proposed to achieve these risk reductions. The first track refers to actions by individual banks. The report calls on banks to immediately apply an appropriate credit control process to their settlement exposures. The second track involves the provision of risk reducing multi-currency services by industry groups. The report encourages industry groups to construct and implement settlement services as it is believed that the private sector can provide these services more efficiently than the public sector. The third track addresses central banks to induce private sector progress. The statements of the Allsopp-Report can be interpreted as a wake-up call for the industry. The report clearly pointed out that progress in settlement risk reduction is necessary. In that, the Allsopp-Report set the basis for initiatives such as CLS, ECHO and Multinet (see chapter 4).

3.3.5 Progress-Report

After the Allsopp-Report had invoked developments to reduce settlement risk in foreign exchange transactions, the CPSS published a report in 1998, to look at the progress achieved by the three-track strategy proposed two years earlier. The report "Reducing Foreign Exchange Settlement Risk" (CPSS 1998) summarizes the key findings regarding the three tracks. Referring to the first track, individual banks partly managed to reduce their exposures and treat foreign exchange settlement risk like other credit exposures of the same size and duration. A significant increase in awareness at senior management levels was noted. Further near-term improvements could thus be expected. Actions taken by the second track, the industry groups, include the advancement of bilateral netting arrangements provided for instance by FXNet, Valunet, or SWIFTNet Accord (see 2.5.16 and 4.1.3). Other industry groups worked on alternative approaches like contracts for difference (CFDs) to replace traditional foreign exchange trades. CFDs settle by paying the difference between the contract rate and the settlement rate multiplied by the notional amount of the contract (see 2.4.2). The report furthermore mentions the company CLS Services which "has been set up to develop plans for a "continuous linked settlement" bank (the CLS Bank) to settle foreign exchange deals" (CPSS 1998). Central banks which represent the third track of the CPSS strategy improved their wholesale payment systems and extended the operating hours of the systems. Both actions were assumed to provide potential benefits for settlement in foreign exchange transactions. It was also noted that relevant cental banks were about to establish relations to CLS Services. Even though actions on all three tracks had been undertaken, the report concludes that further progress is necessary. It is stated that 60 percent of the banks monitored still underestimate their exposures. Hence, the three-track strategy is reaffirmed and individual banks, industry groups, and central banks are equally encouraged to further push the issues. The G10 central bank governors invited the Basle Committee on Banking Supervision to provide international supervisory guidance for banks on settlement risk management in line with the recommendations of the Allsopp-Report.

3.3.6 Supervisory Guidance-Report

As a result from the invitation by the G10 central bank governors the Basel Committee on Banking Supervision released a report on "Supervisory Guidance for Managing Settlement Risk in Foreign Exchange Transactions" (BCBS 2000). The report states the nature and duration of foreign exchange settlement exposures and provides guidance to banks how to manage it. As mentioned at the beginning of this section the summarized reports significantly influenced the developments regarding risk reducing settlement arrangements for foreign exchange deals, and in that, played a key role regarding the development of the CLS system.

3.4 Chapter Summary

Since 1974 a number of incidents triggered central banks' attention regarding credit risk exposures during settlement. The Bank for International Settlements established in 1990 the Committee on Payment and Settlement Systems. The reports published by the committee provided guidance regarding developments of new settlement standards. Figure 3.4 relates the historic settlement disruptions to the reports of the Committee on Payment and Settlement Systems to provide a chronological overview of the most important steps that led to the initiative to build the CLS system.

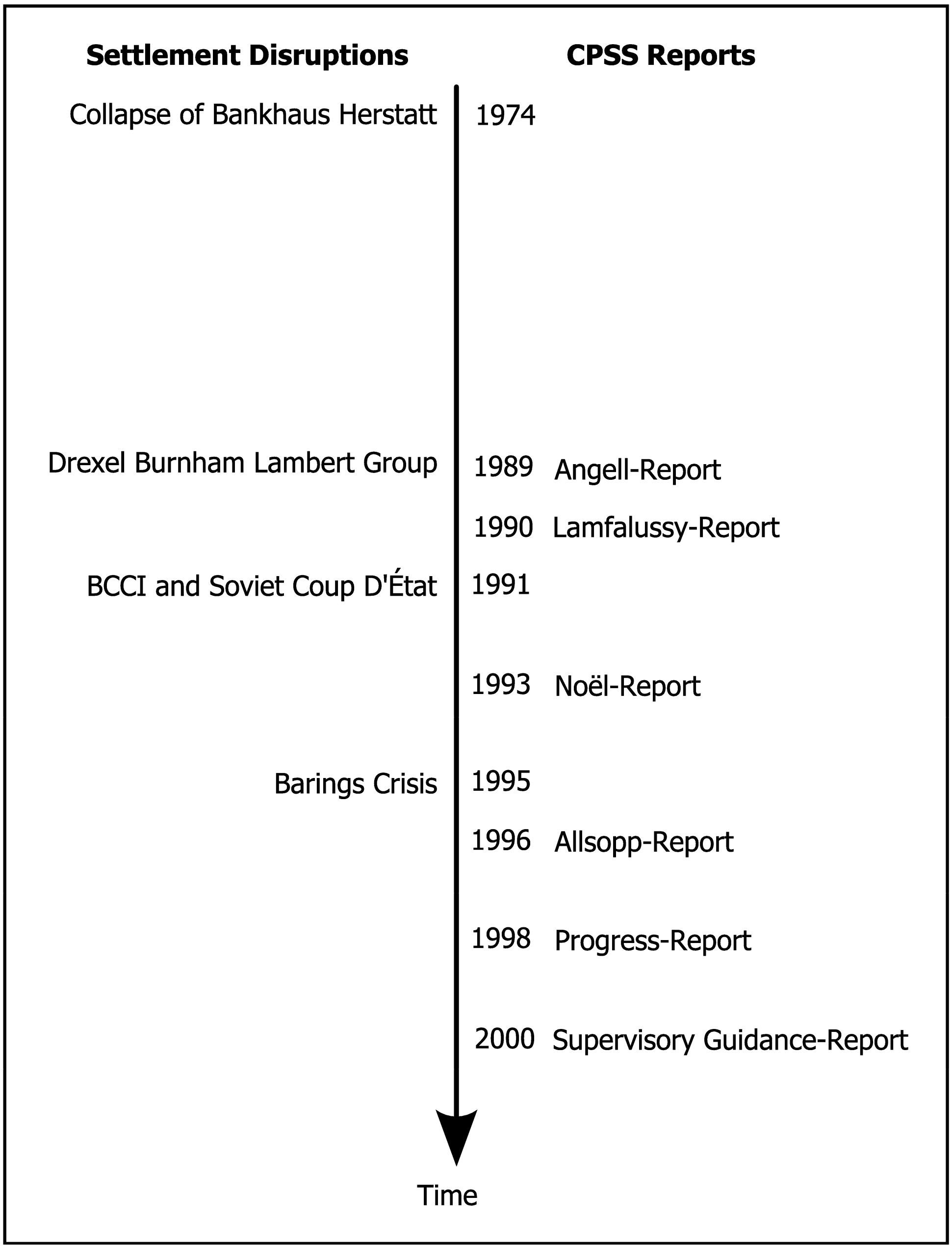

Figure 3.4: Chronological Overview (author).

Chapter 4

History of CLS

Originally, the CLS system was supposed to go live with seven currencies sometime during the year 2000. The project itself and the way it was managed turned out to be much more complex than expected and delays were inevitable. This chapter looks at the project's milestones and shows the difficulties that had to be dealt with. It describes the way from an ambitious project to an international industry-owned risk management facility. The chapter is split up in four time periods. It starts with the project's birth in 1994 and describes the planning and growth stage until CLS was incorporated in 1997. The second period, lasting from 1997 to 1999, outlines the history of CLS as a legal entity of its own until the receipt of a banking licence at the end of 1999. The third period looks at the years from 1999 to 2002 and is dedicated to how the system was brought to life. The last section brings up some issues that emerged since the system went live. CLS is a trademarked term within the financial service industry. It may only be used with references to CLS Bank or CLS Services Ltd. As CLS Bank did not exist prior to 1999, in the following text the term CLS refers to CLS Services Ltd. prior to 1999 and to CLS Bank thereafter. The chapter is based on historical primary sources. The corresponding documents are referenced as "CLS".

4.1 The G20 Meetings 1994 - 1997

The Group of 20 (G20) was formed in October 1994 as a common interest group of senior bankers from large international financial institutions whose business includes significant large value cross-border payment activities (CLS 1995*e*). After the threat of the Bank for International Settlements to impose restrictions to reduce settlement risk (see 3.3.4), the G20 took initiative and started to meet on a regular basis to work out a private sector solution to reduce credit risk in foreign exchange transactions. At their first meeting in late 1994, three alternative models to solve the problem were proposed (see 4.1.1). To check the practicability of these models and to prepare selection criteria, the G20 formed a so called Operational Feasibility Working Group (OFWG). Based on the reports of the OFWG, the G20 decided for the third of the three alternative models. Subsequently, the OFWG started to exclusively work on the feasibility of that particular model, a continuous linked settlement solution. During 1996 and 1997 the G20 regularly met to set up the incorporation of a corresponding entity. This time period, from the beginning of 1996 until July 1997, may be considered as the preparation for the actual CLS Bank. Based on original records the following paragraphs describe the main issues that required consideration during this time.

4.1.1 Selection of the Model

The following three models had been proposed in late 1994:

1. Gross matching with earmarking: settlement via national RTGS systems with final transfer of earmarked funds only if counterparty settles respectively. PvP is achieved by using message switching to coordinate the local payment systems in a way to ensure that all of a set of transactions are completed or none. The concept is set up as a technological "superstructure" operating on the existing RTGS systems.

2. Matching with netting: solution offering matching and reporting services combined with a multilateral net PvP mechanism via self collateralization. Net debit participants are obligated to fulfill their pay-ins by a specified deadline. The system monitors payments received on the basis of real-time information from the local RTGS systems and releases payments owed to participants that fulfill their obligations. Matched instructions are revocable during the pre-settlement period but become final with the start of the settlement period. Each participant settles directly with special accounts in its local RTGS system. While model 1 and 3 are set up as a "if you don't pay, then I don't pay"-concept, model 2 follows the idea of a "If I do pay, then I will get paid"-mechanism.

3. Clearing house bank: PvP mechanism with continuous real-time linked processing and item-by-item settlement through the posting of debits and credits to member accounts in a multi-currency clearing system. Later on called CLS.

The third alternative, the idea of a PvP mechanism was developed during the analysis of model 1 and 2 (CLS 1995*c*). On their meeting in May 1995 the G20 reviewed the three models and short-listed two of them (CLS 1995*b*). After voting, the G20 members agreed to select models 2 and 3 for further evaluation. They appeared to have superior functionality to model 1 in terms of information provided to participants and regarding liquidity requirements. Thus, the OFWG kept on working on the evaluation of model 2 and 3. In October 1995 the OFWG set up the following five guiding principles that reflect the Lamfalussy standards (see 3.3.2) as well as the criteria defined by the G20 themselves. The G20 should use them to evaluate the two models (CLS 1995*d*): (1) the system must reduce risk (credit risk, liquidity risk, and systemic risk), (2) the system must be safe and sound (well-founded legal basis, operationally workable, and high degree of operational reliability), (3) the liquidity pressure created by the system must be manageable, (4) the system should be commercially viable, and (5) the system must function in a manner that is consistent with the public policy objectives of the relevant central banks. After comparing the models according to these guiding principles, the OFWG concluded that both models were operationally feasible (CLS 1995*a*). However, for both models a number of legal and regulatory issues had yet to be resolved. Most working group members agreed that model 3 provided superior performance from an operational and liquidity management standpoint due to the continuous settlement process. Model 2, as a netting system, only offered a determined number of concentrated settlement sessions. Model 3 would thus cause considerably lower liquidity and collateral costs. From a technical perspective, the OFWG believed that both models would be implementable within three years if the expertise of existing service providers was utilized and with sufficient central bank support. Liquidity impact simulations conducted by the OFWG at the end of 1995 showed that model 3 provided substantially superior operational performance and liquidity management due to its continuous settlement process (CLS 1996*p*). Also regarding collateral cost, model 3 featured more favorable properties (CLS 1996*m*). Consequently, in January 1996 model 3 was approved by almost all G20 members. Only one European bank was still an objector of model 3 at that time (CLS 1996*c*). Another European G20 bank who was a strong supporter of model 3, finally rendered the necessary lobbying to convince the rest of the opposition (mostly stakeholders of already existing systems (see 4.1.3)) (CLS 1996*d*). By the beginning of 1996, model 3 had also won central banks' favors (CLS 1996*n*). At their February meeting in 1996, the G20 voted to adopt model 3, the Continuous Linked Settlement approach and reaffirmed its commitment with an implementation target of 3 years (CLS 1996*g*).

4.1.2 Transforming the Project into a Company

After having decided for model 3, the time period from May until December 1996 was called business requirement specification (BRS) phase. The BRS phase included the development of business specification requirements and the approaching of Multinet, ECHO, and FXNet to ask them for cooperation (see 4.1.3) as well as to identify a suitable jurisdiction and get necessary transaction data from SWIFT to run simulations (CLS 1996*g*). In March 1996 the following issues were identified as critical project risks in this phase (CLS 1996*f*): Under-resourcing and aggressive timescales, disability to work with the existing netting systems, missing data for modelling, and the ability to analyze the impact on domestic markets to the satisfaction of the central banks. Having established the business requirement specification in late 1996, the G20 proposed to incorporate a CLS core organization to go on with the next project phase, the formation of CLS Bank. A board of directors out of G20 members should be established to supervise the project at business level (CLS 1997*g*). This project management structure was supposed to evolve to become the management of the future CLS Bank. At a technical level, SWIFT was proposed to be the future technical operator once the system was live. The G20 should remain advisor (CLS 1997*n*). At the G20 April meeting of 1997, it was decided to be ready for a new project phase and to form a company as of July 1, 1997, with the purpose to create and develop CLS Bank. It would be incorporated as a private company with the legal name "CLS Services Ltd." and should be open to further banks as shareholders, not only the ones represented in the G20. The first board meeting for CLS Services Ltd. was scheduled for 22 July, 1997 (CLS 1997*m*). Prior to the incorporation of CLS Services Ltd. in July 1997 the G20 and its respective working groups were absorbed by several issues which are summarized in the following paragraphs.

Estimating Project Costs

At the end of 1995 the OFWG tentatively estimated project costs of USD 40 million to build the central PvP system and USD 20 million per year to run it (CLS 1995*a*). The business requirement specification phase (see p. 53) from May until December 1996, was financed by contributions from the G20 members. Each member had committed USD 1 million that was called in step by step over the project phases. For the business requirement specification phase a tranche of USD 135'000 had to be paid which resulted in total funds of USD 3 millions for this seven months period. Expenditures were fully covered by this income (CLS 1997*p*). For the subsequent period, January to June 1997, the business plan projected a total income of USD 1.3 million contributed by members. Again this amount covered total projected expenditures (CLS 1997*n*). To become a shareholder in the newly established CLS Services Ltd., a financial commitment of USD 1 million was required as of July 1, 1997 for new members (CLS 1997*l*). These member contributions widely covered the expenditures until summer 1998 when a recapitalization was planned (see 4.2.3). To estimate total project costs, the G20 commissioned an economic analysis of the CLS Bank in 1997. The analysis estimated total building cost of a standalone CLS Bank of USD 70 to 80 million. The annual cost to run the system were estimated to USD 30 million which was considered to be a conservative guess (CLS 1997*k*). Compared to the number estimated in 1995, projected costs had already doubled. The realized costs, however, ended up to be well over USD 200 million.

Choice of Jurisdiction

As it was clear that at some point a legal entity must be incorporated to go on with the CLS project, a proper jurisdiction had to be found. In March 1996 several criteria which should be met by a suitable jurisdiction for the future CLS Bank were set up (CLS 1996*f*). To start with the selection process, a basic questionnaire was sent to eight countries. The questions were to be answered by these countries in conjunction with suitably qualified in-house legal experts. Canada, Japan and The Netherlands immediately reported that their countries should not be given further consideration. The results from UK, USA, France, Germany, and Switzerland indicated that there were insufficient arguments to disqualify any of them at this stage. The G20 considered it reasonable to focus on the two countries in which the existing Net Systems were domiciled (UK and USA) as the plan was to cooperate with them (see 4.1.3) (CLS 1996*j*). In January 1997, the G20 conducted a more detailed legal survey of the remaining five jurisdictions. The survey covered four interrelated issues (CLS 1997*r*): (1) funding finality (whether CLS might be required to repay an amount paid to CLS by a member), (2) settlement finality (whether CLS, settling linked payments, might be required to reverse any payment to a member's CLS account), (3) unity of account (whether CLS might be prevented from treating its exposure to a defaulting member as a single net amount, effectively applying long positions as collateral for short positions), and (4) securities collateral (whether there might be restrictions on the ability of CLS to rely on securities provided by way of collateral to CLS to cover any resulting net exposure to that member. The survey brought up questionable issues regarding a US location (New York) of the CLS Bank. The US Office of Foreign Asset Control (OFAC) rules allow to block funds of foreign banks on CLS accounts for political reasons. Furthermore, approval of the Federal Reserve System (FED) could take several years (CLS 1997*h*). Besides this issue London and New York did not show substantial differences and the decision could be expected to be based on political aspects. Therefore, the name CLS Bank was reserved in both, the UK and US to ensure that it was still available when CLS Bank was finally formed (CLS 1997*m*). Eventually the G20's discretionary decision made UK the home of CLS Services Ltd.

Legal Issues in Switzerland

To explore legal issues such as finality of payments and unity of accounts in the countries that were planned to have future access to the CLS system, the G20 sent out a request for proposal to local legal counselors in the respective countries (CLS 1996*o*). In Switzerland the G20 decided to engage legal counsel by Niederer Kraft & Frey. At the end of 1996 Niederer Kraft & Frey handed in their in depth legal analysis, which raised questions regarding funding finality, settlement finality and unity of account under Swiss insolvency procedures (CLS 1996*b*). These issues had to be solved in order to enable the Swiss franc to participate in CLS. The principal concerns noted by Niederer Kraft & Frey were related to the rules affecting pay-ins and settlements after an application for the opening of composition or moratorium proceedings or after an order declaring bankruptcy. The underlying problem was due to the fact that the Swiss law did not provide a practical means for CLS Bank to be assured that it will be informed prior to a bankruptcy order (CLS 1997*e*). From the time of the order, the failing bank was prohibited to move its assets. However, as such an order could become effective without CLS knowing it, CLS could still have settled the failing bank's obligations. As a consequence the liquidator could reclaim all pay-ins of the failing bank that were conducted after the opening of the bankruptcy order. In this special case finality of payments would not be assured. The issue could have been addressed by making arrangements with the Swiss Federal Banking Commission (SFBC) so that CLS Bank would receive notification of bankruptcy proceedings in advance of the order. CLS Bank could then cease processing respective instructions before the order is made. However, it was not clear that the SFBC itself would have advance notice of any application for the opening of composition or moratorium proceedings (CLS 1997*e*). In fact, there was no legal assurance that they would receive notification in advance as any cantonal court could open a bankruptcy order without informing the SFBC. This issue, that under Swiss bankruptcy law the finality of payments in SIC (Swiss Interbank Clearing) may not be guaranteed can be considered as the detection of a legal loophole. It could have seriously compromised not only the participation of the Swiss franc, and thus the participation of any Swiss bank in the CLS system but also the SIC system. Even though the practical relevance of a bankruptcy case with the SFBC not being informed in advance was considered negligible, it was clear that a new solid legal basis to address this issue was needed to fulfill the CLS requirements (CLS 1997*j*). As a corresponding legal adaption seemed impossible to be achieved in a timely manner, the Swiss Federal Banking Commission was requested to officially confirm to CLS Bank the irrelevance of such a case. In spring 1998 the SFBC formally decided to include CLS Bank in its notification procedure prior to the time when an order becomes effective (EBK 1998*a*). Furthermore CLS Bank was informed that amendments of the Swiss bank bankruptcy law would be initiated in late 1998 (EBK 1998*b*). Based on these statements Niederer Kraft & Frey rendered a second report which was submitted to CLS Bank in the year 2000. They finally concluded that under current Swiss law there is no reason that CLS Bank might be required to reverse any payments made in the settlement process (Niederer Kraft & Frey 2000). Today the issue is solved on a sound legal basis.

Membership Criteria

Due to the large values that were planned to be settled, it became obvious that CLS Bank must require members to demonstrate that they are financially and operationally capable of meeting all the requirements implied by this scale of operation. Therefore, at the beginning of 1997 CLS Bank suggested the following membership criteria for its members (CLS 1997*c*): applicant must (1) designate an eligible home country, (2) be prudentially supervised by an acceptable authority, (3) provide an independent legal counsel opinion regarding the absence of legal impediments interfering with the ability to meet its obligation to CLS Bank, (4) have a minimum long term debt rating of A-, (5) have a minimum Tier 1 capital of USD 3 billion, (6) meet certain volume thresholds at the beginning, (7) have access to intra-day funding, (8) commit liquidity facilities to CLS Bank, (9) meet all technical and operational requirements imposed by CLS Bank, and (10) accept the short position limits set by CLS Bank. If and how these rules would cover the relationship between CLS Bank and its members would depend on the location of the CLS Bank which at that point had not yet been decided.

Business Requirement Specification

In October 1996, a generic framework for the business case was introduced (CLS 1996*l*). It should help the G20 banks to prepare their own business cases responsive to their own bank's unique risk management concerns, business mix, system characteristics, and investments (CLS 1996*a*). It would thus support the banks in their decision whether to invest in the development and the implementation of the CLS system. It provided a comprehensive list of impacts that CLS was expected to have on member banks in the areas of risk reduction, cash management, trading, operations, and systems. It classified these impacts according to benefits and drawbacks. The business case, however, did not contain information on the cost to build and operate the system. The issuance of a request for proposal which was scheduled for the end of 1996 would clarify these points (see 4.2.1). In late 1996, the working group presented a first version of the business requirement specifications for the CLS system (CLS 1996*l*). The working group was assigned to put together the system requirements in terms of volume estimates, interfaces, contingency and MIS by the end of January 1997 (CLS 1996*i*). At their February meeting, the G20 accepted the business requirement specification as an effective and complete design (CLS 1997*n*). To develop the CLS design and to assess its potential performance, a computer simulation model had been used. The model was initially run with statistically generated data. At the beginning of 1997 a sample of G20 transaction records was collected by SWIFT and FXNet in accordance with the involved banks to produce estimates of the market size and to provide transaction data for the simulation. PriceWaterhouse acted as data custodian. For the G20 transactions in the seven CLS currencies, the daily market size was estimated to about USD 500 billion (counting both legs). For 40 banks the market was assumed to be almost twice as large. Settlement value for all counterparties in the seven CLS currencies was estimated to add up to USD 2'700 billion. The simulation with real transaction data confirmed that the CLS design worked effectively and efficiently (CLS 1997*u*).

RTGS and Central Bank Access

While working on the business requirement specification it became clear that to avoid the cost and operational requirement of establishing a branch of the future CLS Bank in each country, it was necessary to request from each central bank remote access. CLS Bank should maintain an account at each central bank and be remotely connected to the local RTGS systems from the country where CLS Bank would legally and physically be located. To discuss this issue, the OFWG regularly met with the Steering Group on Settlement Risk in Foreign Exchange Transactions, a sub-committee of the CPSS during 1996 and 1997 (BIS 1996). By spring 1997, the following three central bank service requirements to support CLS operations were identified (CLS 1997*o*):

(1) to move CLS funds to and from its members, a central bank account and membership in the respective RTGS is needed, (2) the central bank access must allow remote initiation of payment instructions and real-time balance reporting, and (3) adequate operational and computer back-up procedures must be available. Besides the options of joining the RTGS systems directly or indirectly, the preferred solution which met these demands was based on a nostro relationship of CLS Bank with the respective central banks. Due to the fact that the connection to a multitude of RTGS systems required complex technical interfaces as well as strong and comprehensive IT support functions, it was recognized that this solution could become prohibitively expensive. It was concluded that the G20 should form a dedicated project team that would negotiate the solutions with each central bank individually (CLS 1997*j*). To evaluate the different alternatives and to identify a cost effective approach, the project team started off with a questionnaire that was sent to the relevant central banks (CLS 1997*d*). By the end of 1997, most key central banks had been visited and the remote access requirements had been discussed. It was the aim to reach mutual commitments with each country regarding detailed solution specifications by March 1998 (CLS 1998*e*). Of the initial seven currencies that were planned to settle in CLS, the operating hours of payment systems in four of them already overlapped sufficiently. For three of them, these being AUD, CAD and JPY, it was necessary to extend operating hours. Technical and operational infrastructure changes had to be determined by the respective central banks and actual implementation procedures had to be coordinated with CLS Bank (CLS 2001*d*).

4.1.3 Other Initiatives

Under the pressure of the central banks there were also several other foreign exchange settlement solutions that were developed by private sector initiatives besides the one of the G20. At the end of 1996, the following systems were in operation or in their development phase:

- FXNet: offers a bilateral netting service to various banks.
- Multinet International Bank (Multinet): clearing house concept with counterparty substitution intending to offer multilateral netting. During the mid-nineties it was only offering bilateral netting via its Valunet service, a real-time, cash flow obligation netting and risk management system, similar to FXNet. Multinet suffered from discussions regarding regulatory issues and never found the critical mass needed to get full operations started.

- Netting the Nets: was yet in development. Funds netted by FXNet were planned to be transferred to Multinet where they would be netted once more. Multinet would act as counterparty.

- Netting Plus: a concept that addressed bilateral risk reduction by rolling cash flows forward and only settling mark-to-market valuation of the closed out contracts (see 2.4.2). The idea was based on the assumption of consistent two-way business.

- Exchange Clearing House Ltd. (ECHO): offering multilateral netting through a concept called "open offer" and contract substitution. Was at operation since 18 August 1995, but was running at loss.

For several reasons such as high entry barriers and a gridlock situation regarding cooperation, none of these concepts had the potential to penetrate the market. A combination of some of these netting systems and the CLS system looked like a promising approach at this stage (CLS 1997*v*). But the mainly US shareholders of Multinet as well as the European ECHO shareholders blocked each other while the third group of neutral banks simply kept out. It was feared that this gridlock could be carried forward to CLS. Notwithstanding, the G20 identified the three netting systems, Multinet, ECHO, and FXNet ("the Net Systems") collectively as the preferred partner in achieving the CLS solution (CLS 1996*h*). This conclusion helped to get all involved parties to the side of model 3 (see 4.1.1) as many of them were also owners of the Net Systems (CLS 1996*j*). In February 1996, the first meetings with the Net Systems took place and CLS was presented (CLS 1996*f*). After two meetings and further telephone conferences the Net Systems did not seem willing to cooperate due their fear of competition in case CLS will be successful and due to the fact that their approach was more similar to the rejected model 2. Discussions rather pointed to a merger scenario. The G20 at this time officially believed that CLS and some of the Net Systems' services would co-exist in the future as complementary processes, providing market participants with the ability to manage their foreign exchange risk in a variety of ways (CLS 1996*j*). However, other opinions found a co-existence rather questionable since foreign exchange multilateral netting would not only be redundant but even unnecessary in the first place (CLS 1996*e*). The G20 agreed on creating an integrated solution that would bring the Net Systems and CLS together (CLS 1996*k*). In December, Multinet and ECHO finally agreed to establish a framework for creating an integrated industry-wide system to provide both, netting and CLS (CLS 1996*i*). In February 1997, the G20 accepted the following target design. The cooperation should be set up as a holding company with three subsidiaries under UK law: a combination of

ECHO and Multinet, FXNet and CLS Bank (CLS 1997*i*). Discussions with ECHO and Multinet regarding the necessary merger started immediately. In June 1997, ECHO and Multinet agreed to merge their companies under a common owner, Netting Holdco, located in London. The merger would lead to ECHO being the netting counterparty and Multinet being the sole settlement banker for ECHO. Netting Holdco would then approach FXNet for the purpose of inviting it to cooperate (CLS 1997*q*). In a next step Netting Holdco was planned to be merged with CLS Services Ltd. In September 1997, the proposal document for a share sale agreement was ready (see 4.2.2) (CLS 1997*s*).

4.2 CLS Services Ltd. 1997 - 1999

In summer of 1997, the CLS project transformed into an own legal entity. CLS Services Ltd. was incorporated and therewith the project entered a new stage.

4.2.1 Procurement Strategy

In view of the considerable risk associated with the CLS project and to avoid a large increase of headcounts it was concluded that an optimal approach to procurement for CLS Services Ltd. would be to select a single prime contractor who agrees to develop and to operate the system (CLS 1997*f*). As a first step, about 20 suppliers were asked to provide information regarding their capabilities to ensure that the ones that were asked to respond to the request for proposal were able to meet the requirements. Based on the results derived from the request for information, 9 vendors were invited to respond to the request for proposal as potential prime contractors for the supply of the required services. In October 1997, the final version of the request for proposal was approved and sent out to the potential vendors. There were three potential contractors, British Telecom (BT), EDS and IBM that came up with viable offers and showed a strong interest in competing. SWIFT decided not to bid as a prime contractor but committed to offer its full range of services to any of the three remaining potential contractors (CLS 1997*b*). It was planned to award the contract at the end of April 1998 (CLS 1998*e*). Up to then central bank issues regarding remote access requirements were supposed to be resolved (see p. 54). At the board of directors meeting in late April 1998, IBM was decided to become the prime contractor to develop the CLS system. BT disqualified due to uncompetitive pricing. EDS and IBM issued comparable offer in every respect. CLS management preferred

IBM(CLS 1998*c*). The application was planned to be developed by IBM Global Services in Belgium, with assistance from ATOS, a French software company (CLS 1998*k*). Even though at the board meeting in April 1998 it was envisaged that negotiations would be closed by May, it took another two month to get the contract signed on 22 July 1998. It took more time than expected to develop the contractual mechanisms for controlling costs. The scope of the contract with IBM covered three main phases. First, the design and build of the CLS system, second, the implementation of the system in IBM's own data centers, and third, operation and maintenance of the system for an initial period of five years after going live (CLS 1998*l*). At the same time SWIFT was contracted to design and implement a member network system over an IP network known as SWIFTNet (see 2.5.16) and to provide consultancy services regarding correspondent banking (CLS 1998*l*). Both agreements were targeted to go live in summer 2000.

4.2.2 Merger with ECHO and Multinet

The completion of the merger between CLS Services Ltd., ECHO and Multinet (Netting Holdco) was scheduled for the end of 1997. As mentioned in section 4.1.3, by September 1997, the proposal document for a share sale agreement had been finalized. Regulatory approval from the Bank of England, the Federal Reserve Bank of New York and the New York State Banking Department had still been outstanding. The final closing date was ultimately dependent on the timing of their actions. However, on 17 December 1997, ECHO and Multinet became wholly owned subsidiaries of CLS Services Ltd. It was clear that after the completion of the merger the Board Committees of the CLS Services Ltd. needed to expand. An effective distribution of responsibilities, provision of appropriate segregation of duties and control as well as an effective management of this integrated industry facility had to be implemented (CLS 1997*t*). The revised roles of the CLS Services Ltd. allotted the following 6 committees[1]: (1) Executive Committee (strategic development and operational oversight), (2) Admissions Committee (development of shareholder criteria and marketing plan for acquisition of new shareholders, was abolished at the end of 1998), (3) Audit Committee (performance measurement and reporting), (4) Nominating and Directors Affairs Committee (director selection and qualification supervision), (5) Operations and Information Technology Committee (oversight of system architecture development and business plan implementation), and (6) Risk Management

[1] This structure underwent numerous changes over time. For the current company structure refer to chapter 5.

Committee (development of risk policies and management of credit and liquidity issues). On the operational side it was discussed how netting provided by ECHO and Multinet could be integrated in the services offered by CLS. The idea was to process the multilateral net settlements in CLS. The netting mechanism would reduce pre-settlement risk while the CLS mechanism would eliminate principal risk. CLS and netting could thus operate as complementary services. In a first step it was concluded to enhance ECHO's platform and to discontinue Multinet's multilateral netting operations and to transfer available staff and resources to CLS. As the inconvenience of this decision was entirely born by the former Multinet users, a transition period was granted. Multinet's Valunet (see 4.1.3) should be continued while the affected banks were assisted in adapting to the ECHO system (CLS 1998*i*). On 14 July 1998, Multinet's directors resolved to liquidate the bank and to wind up its affairs with the target to finally close down operations in January 1999 (CLS 1998*b*). Pursuant to the applicable filing with the New York State Supreme Court and the New York State Banking Department, Multinet was effectively dissolved on 4 May 2000 (CLS 2000*e*). The decision to keep ECHO's operations up was based on the assumption that the members would use both, a principal risk reduction (CLS Bank's PvP mechanism) and a pre-settlement risk reduction mechanism (ECHO's multilateral netting). ECHO was therefore planned to be upgraded with respect to risk management and some additional services. These changes were designed to make ECHO more appealing to a larger number of users and thus to generate substantial revenue growth (CLS 1998*f*). However, due to serious concerns regarding the legality of certain ECHO services under the US Commodity Exchange Act[2] and the introduction of the Euro, the Y2K problem[3] as well as due to the expected going live of the CLS system, banks simply did not have capacity nor interest to adapt to another new system. The projected growth did not occur. At the end of 1998, the group agreed that the current ECHO business was not commercially viable given the available capital. It was estimated that if the operation would be continued, all capital held in contingency for ECHO would be exhausted by early 1999. Hence, it was considered whether

[2]The US Commodity Exchange Act (CEA) prohibits the sale or offer of future contracts in or from the United States except on organized exchanges that are regulated by the Commodity Futures Trading Commission (CFTC). Under the Treasury Amendment to the CEA, bilateral off-exchange transactions in currencies between large financial institutions are permitted as long as they are not entered into a market that can be considered a Board of Trade. The term "Board of Trade" had generally been interpreted to mean centralized execution facilities that can be used by multiple participants. However, the CFTC had recently begun an investigation of a clearing house offering comparable services to ECHO.

[3]Checking and upgrading the IT systems for the new millennium.

the service should be abandoned or reconfigured in a way that would reduce costs and develop a better fit with CLS (CLS 1998*g*). Modifications of the ECHO service were rejected mainly for legal, regulatory and market acceptability reasons. Hence, at their February board meeting in 1999, CLS's management recommended to suspend the ECHO system (CLS 1999*e*). At an extraordinary general meeting on March 15, 1999, the recommendation was approved by a majority of 52 against 6 shareholder votes (2 were invalid) and the suspension process was started (CLS 1999*c*). On 30 April, 1999 the service of ECHO was discontinued (CLS 1999*a*). Despite the plan to cooperate and integrate the Net Systems, they were merged into CLS and subsequently both closed down.

4.2.3 Recapitalization in Summer 1998

CLS' initial owners had provided aggregate funding commitments of USD 20 million for the first year of development (see 4.1.2). This capital was called in step by step and was intended to cover expenditures through mid 1998. At this time, additional capital was needed. At the end of 1997, the costs to develop the CLS system were estimated at USD 70 million to USD 80 million (CLS 1997*a*). Including adequate contingency funds, total capital requirements for the three year period from mid 1998 to mid 2001, were assumed to be about USD 150 million. To raise these funds, new participating banks had to be found. The business plan as of April 1998 indicated a per capita commitment for a new owner of USD 3.5 million and another USD 2.5 million contribution for existing owners (as existing owners already had committed USD 1 million) (CLS 1998*d*). Immediately after the recapitalization, no shareholder should have more than five percent of the voting rights in the company. This provision led to discussions due to the fact that several mergers had taken place among the G20 banks. In July 1998, an ownership of 60 shareholders had been reached and a successful recapitalization was announced to the public (CLS 1998*j*). A total commitment of USD 160 million from 60 subscribers in 14 countries had been achieved.

4.2.4 Contract Issues with IBM

CLS Services Ltd. had completed its software vendor selection process in April 1998 and IBM, as the preferred supplier, had signed the procurement contract in July 1998 (see 4.2.1). The winning bid totalled USD 54 million building cost, USD 4 million for initial deployment, and USD 2.6 million for pre-testing the system as well as USD 49 million for the five year maintenance period after the going live. Including contingencies of almost USD

30 millions, CLS calculated total project costs of about USD 130 million. Based on the business requirement specifications established one year earlier, in spring 1997 (see p. 53), IBM immediately started to work out the functional requirements specifications (FRS) in cooperation with CLS. The business requirement specifications were relatively simple compared to the final FRS. Faced with this level of complexity, IBM changed its position and claimed that the scope of the development had increased considerably. CLS management disagreed and price negotiations recurred (CLS 1998*h*). After an extensive review of the FRS, the two parties agreed on 1'480 additional programmer days that would be required. Based on this, IBM proposed the following three options to CLS. First, to cut out the user member functionality (see 5.1) and complete the rest of the system by 30 June 2000 as targeted. Second, to split the project in two phases and deliver the user member functionality later. Third, to complete the full system with a delay of 70 days. All three options included cost increases of up to 20 percent. In January 1999, after a sound evaluation of IBM's propositions, CLS management decided to proceed with option three. A delay of 70 days was considered less costly than going live with a system that does not cover the industry's needs and would thus not reach the necessary degree of market penetration required by the regulators. Going live was therefore rescheduled for October 2000 (CLS 1999*d*).

4.3 CLS Bank International 1999 - 2002

4.3.1 Structural Changes

In June 1999, CLS Services Ltd. proposed to form a subsidiary that was to be incorporated as a bank under the Edge Act of the United States of America under the name CLS Bank International (CLSB). The application was filed with the Board of Governors of the FED on 6 August 1999. CLS Bank was intended to function as a special purpose, multi-currency bank which would provide its members with continuous linked settlement services. The form of an Edge Act corporation with centralized US regulatory oversight and no restrictions on citizenship for directors, was considered the most flexible structure for this purpose. The bank was planned to be headquartered in New York and to have supporting operations in London and Tokyo (CLS 1999*b*). On 1 November 1999, the FED approved the application (CLS 1999*h*), and CLS Bank International in New York became a sister company of CLS Services Ltd. Two years later, in June 2001, the board approved a new CLS Group corporate model that included the formation of a new CLS Group holding company based in Switzerland (CLS 2002*g*) which set the base for CLS's current structure (see chapter 5).

4.3.2 First System Tests

In order to generate sufficient volume during the start-up phase of the system, a roll-out strategy was planned. The core programming of the system was completed in April 1999. This enabled the first phase of system testing, defined as integration testing. Four shareholders assisted the integration testing phase; Barclays Bank, HSBC, J.P. Morgan and UBS. These four test banks were called beta banks. The second testing phase, the Operational Trials and Acceptance process (OTA), was planned for the second half of 2000. Within this phase another 16 shareholders, named the millennium banks, should enter the live testing. In the third wave, soon after the OTA, further 11 banks were to go live (CLS 1999*h*). CLS Services Ltd. requested the respective shareholders to sign a letter of intent under which each bank committed to start using CLS Bank for the eligible currencies within a specified time frame (CLS 1999*g*). However, programming by IBM and beta bank testing did not progress according to the time line and delays became inescapable.

4.3.3 Project Delays

After due discussions and renegotiations regarding the procurement contract at the end of 1998, IBM and CLS agreed on an accepted delay of 70 days (see 4.2.4). One year later, at the end of 1999, it was clear that the go live date again had to be rescheduled. It was realized that the FRS were not stable and IBM denoted them as partly unclear. With hindsight the CLS board resumed that purchasing a banking system and adapting it to the necessary payment functionalities would have been more appropriate than building a Unix platform from scratch (CLS 2000*b*). For instance, the two data centers selected by IBM were too far apart (40 miles) to use standard Unix products for the mirroring of the databases (CLS 2000*h*). Instead of being able to use one of the existing mirroring products for standard banking systems it head to be developed for the new Unix platform. Furthermore, IBM struggled with personnel issues. In May 2000, Ernst & Young presented the results of a close examination of the project's financial figures and concluded that total costs would increase to nearly USD 300 million (CLS 2000*f*). Compared to the originally planned USD 130 million, costs more than doubled since June 1998 (see 4.2.1). At this stage the FED considered the project to be in serious trouble and advised IBM to be aware of the project's international importance (CLS 2000*a*). Even though IBM had large customer accounts at stake and was threatened with exclusion from other projects undertaken by CLS shareholder banks, it did not assign its claims. Discussions and appropriate actions to turn around the project were pushed by CLS management(CLS 2000*h*). Under a revised time line, IBM was supposed to deliver the integrated system to CLS at the end of February 2001. OTA (see 4.3.2) would then begin in mid April 2001 and end in August of the same year. Business could thus start in September 2001 with a total delay of about 14 months.

4.3.4 Recapitalization in Summer 2000

During the debate with IBM, it became clear that due to the delays, refinancing was necessary earlier than planned. The USD 160 million that were raised two years earlier, in mid 1998, would not be able to cover costs until operational start (see 4.2.3). At the end of 1997, system development costs had been estimated at USD 60 to 80 million. In 2000, after adapting the financial plans to the project delays, total system development costs were projected to be almost USD 300 million. Therefore all shareholders were requested to contribute new equity to raise total funds of USD 115 million (CLS 2000*h*). In order to incentivize all shareholders to make full contributions, it was resolved that lagging shareholders would not be connected to the CLS system until all other paying members first have successfully started operations (CLS 2000*b*). 52 shareholders secured the necessary USD 115 million and recapitalization was successfully executed in June 2000 (CLS 2000*g*).

4.3.5 More Tests, Trials and Delays

The first trial phase including the four beta banks (see 4.3.2) at the end of 2000 was a disappointment. The banks' firewalls turned out to be a difficult issue and made the testing a painful procedure (CLS 2000*c*). Further technical reviews became necessary and more delays foreseeable. On Monday, 11 December 2000, IBM again asked for a delay of another two months. Besides the IBM related issues, everything was well on track and therefore, CLS board was not willing to again rescheduled the go live date (CLS 2000*d*). Instead, the CLS board commissioned a risk assessment of IBM's ability to meet its development commitments and its capability to support the current timetable. Following a minimum risk strategy, it was agreed that CLS's functionality would be delivered in two releases. The first release would enable CLS to operationally go live in September 2001 but with temporary operational redirections. The second release was planned to be introduced in February 2002 and would be focused on eliminating the compromises accepted for the first release (CLS 2001*c*). The year 2001 was planned to be split in two phases (CLS 2001*d*). The testing phase should last from April to July and included extensive assessments of all participants' systems to give confidence to the industry and to mobilize for the start of the second phase, the live trial stage. The key distinction between "testing" and "trialling" in this context is that the latter involves real monetary values passing across the trialling participants' real production systems. During the system integration test (SIT) in June 2001, further delays had to be communicated. As a result of insufficient system stability the time line was extended by another four weeks and the start for the first live phase named CULP (controlled unscripted live processing) was scheduled for 26 November 2001. At this time IBM's and the members' commitments regarding the project were undoubtedly strong. IBM had more than 450 headcounts assigned to the project and more than half of all members were on time with testing and ready for the live trials (CLS 2001*a*). On 3 September 2001, only a few months after the last delay had been announced, IBM once more suggested major revisions to the time line. According to the new proposal, CULP would start more than half a year later, in summer 2002. CLS negotiated a cost cover by IBM which enabled the going concern for its business plan at all. However, discussions at the board meeting in September 2001 made clear that now the point had come that IBM had lost its credibility. IBM project leaders had to admit that the system's maturity had recently been overestimated. Due to missing understanding regarding the business field of CLS, the system had been built far more complex than needed (CLS 2001*b*). Also high staff turnover on both sides aggravated a consistent development of the project. CLS had a new management and the IBM project management had been fully replaced already twice until then.

4.3.6 Bringing the System Live

The year 2002 started by redefining IBM's contract milestones regarding the going live time line. The new schedule is summarized in table 4.1. Before starting with trials (i.e. End to End Trial), the system integration test (SIT), as the last testing phase, had to be completed. As noted before, the term "trial" refers to real values going through the RTGSs while "testing" indicates simulations based on artificially generated transaction data. Even though involving only 7 pilot banks, the end to end trials should prove the functional capability of the CLS system to its member as well as to the industry. In the so called controlled scripted live trial (CSLT) phase a larger number of members would then be connected to the system. However, settlement would still be scripted in the sense that no exceptional transactions are entered to

New Milestone	**Due Date**	**Detail**
End to End Trials	March 2002	Real value flows via local RTGSs
CSLT	May 2002	Trialling with more participants
CULP	June 2002	Live transactions
Ramp-Up Pricing	August 2002	Introduction of pricing per transaction
Release 2 Live	Undefined	Introduction of second release

Table 4.1: New Milestones (CLS 2002*j*).

the system. Only the CULP phase would then allow for real unscripted and therefore potentially high value transactions. Ramp-up pricing was a concept to assure revenues during the starting phase of the system. Members were assigned fixed settlement volumes that they had to pay for whether or not they would use CLS to settle their contracts. As March approached it became clear that the due dates for the different milestones, particularly the start of the End to End Trials, would not be met. While the system had been stable since January 2002, the fine tuning of the different interfaces still caused serious errors during testing. The CLS board though, well aware of IBM's creeping delays, decided not to set an unconditional date to go live. It was considered to be more important to demonstrate the outside world CLS's commitment to quality than to stick to a fixed time line (CLS 2002*b*). End to End Trials as well as the subsequent CSLT and CULP finally turned out satisfactory during summer 2002, and with a delay of more than two years, CLS started service operation on 9 September 2002 with 39 settlement members and 7 currencies (CLS 2002*c*). Figure 4.1 displays the different stages of projet delays. CLS delivered a 100 percent settlement performance ever since with only a low number of minor disruptions.

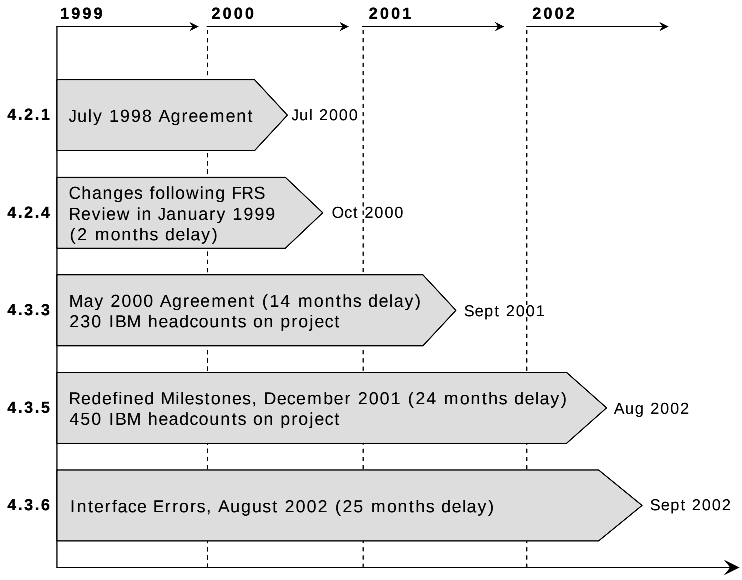

Figure 4.1: Project Delays (CLS 2002*k*).

4.4 CLS in Operation 2002 - 2005

4.4.1 Renegotiating the Service Agreement

During the going live phase, discussions regarding financial issues of the service agreement emerged (CLS 2002*d*). IBM stated that development costs had now significantly exceeded budget (see 4.3.4) and claimed to restructure the original facilities management (FM) and application management services (AMS) contracts.(CLS 2002*e*) To better understand the cost drivers regarding FM for the next ten years, CLS carried out a product review with IBM and at the same time issued a request for proposal to four other potential facility management suppliers. A competitive proposal was achieved by one of them which put CLS in a strong position with respect to the contract negotiation with IBM (CLS 2002*a*). The new service agreements were finally signed at the end of 2002 and still included a cost increase of almost 30 percent compared to the initial agreements. Over a 10 year term, total charges were agreed to GBP 200 million (CLS 2003*h*). As a result of the cost over-runs, CLS found itself undercapitalized. In November 2002, the board decided to close the financing gap by a balanced approach of vendor financing and tariff revision. By 1 July 2003, settlement prices were increased by 10 percent and the remaining deficit was financed by IBM debt. In contrast to a capital increase, this solution spread costs evenly among all sizes of shareholders (CLS 2002*f*).

4.4.2 Business Continuity Planning

The tragedy of September 2001 launched general discussions regarding the need for rapid recovery of critical infrastructure following regional disruptions. In September 2002, the FED, the Department of the Treasury Office of the Comptroller of the Currency (OCC), and the Securities and Exchange Commission (SEC) published a draft version of an interagency paper on sound practices to strengthen the resilience of the US financial system (FED 2003). The paper identified business continuity objectives and sound practices to ensure resilience by minimizing the immediate systemic effects of disruptions on critical financial markets. The core statement of the paper asks for rapid recovery and resumption of critical operations following a widescale disruption or loss of staff in major operating locations. The agencies expected organizations that fall within the scope of this paper to adopt these practices (SEC 2006). Therewith, the paper became a worldwide standard regarding contingency and resilience issues. CLS was identified as one of the organization within the scope of this paper and hence should be able to recover and resume from any disaster within a specified time. It became clear that CLS would need to meet a number of the paper's requirements such as to satisfy a two hour recovery period in the event of any disruption and to establish an "out of region" capability which would be a second site at least 1'000 miles off, able to take over full operations in case of a disruption. As the two IBM data centers, both located at the south coast of the UK, and the IBM command center, located at the East End of London, were close to each other, CLS board was well aware of the implications of the FED's requirements (CLS 2002*h*). Missing the funds to replicate the command center's complete infrastructure outside the UK, it was agreed to expand the New York site to effectively operate the system from there in case of an incident in London. While the CLS applications remained in the UK the business continuity office with its backup systems would be moved to the US. Regarding the data centers, CLS was faced with similar problems. Due to distance constraints of the technology used for the data centers, they must be located within around 70 miles of each other. To fulfill the FED's "out of region" requirement, a different and thus very costly solution would be necessary to build a third data center sufficiently remote from the primary site. Hence, it was agreed with the FED to temporarily delay the movement of the data center to have more time for working on technical progress. The FED accepted a longer term action plan that started off with checking the technical potential regarding the operational systems and staff (CLS 2003*c*).

4.4.3 Service Disruptions

From a service point of view, on 25 March 2003 the only severe operational disruption occurred. Due to a database error, about 30 percent of that day's instructions were rejected and the Asia-Pacific RTGS systems's operating hours had to be extended. While IBM was the initial source of the problem, CLS contributed with late reaction. The situation aggravated as settlement members subsequently did not put the proper level of seniority to the issue. One day later however, on 26 March 2003, the problem was fixed and no service incidences occurred. The rejected instructions that were resubmitted, successfully settled on that day (CLS 2003*d*). Further minor disruptions appeared during the following months such as the one on 27 May. Due to operational errors at CLS, funds were paid out that had not yet been settled. Standard failure management action was taken successfully, the money was called back and settlement was still completed on time (CLS 2003*c*). Settlement volumes increased in line with forecasts and the system proved its resilience ever since. The delivery of CLS Bank has fulfilled the ambitious target to set a new standard of globalization in the industry.

4.5 Chapter Summary

The initial sponsors of the CLS project were a group of twenty international banks (the G20). The G20 established a number of working groups to confirm the viability of a CLS Bank. In July 1997, the G20 created a new company, CLS Services Ltd., incorporated in England. The company was formed to be the organization to fund and build the CLS system. In December 1997 CLS Services Ltd. acquired the entire issued share capital of ECHO and Multinet and discontinued their operations. The acquisition enabled the creation of a single industry facility for the reduction of settlement risk. IBM, being the prime contractor to build the CLS system, soon encountered serious difficulties to implement the required specifications and major delays incurred during the following years. In 1999, the FED approved CLS's application for a banking licence and the CLS Bank International was incorporated as a special purpose, multi-currency bank under the Edge Act of the United States of America. Finally, after a long series of set-backs and with a delay of more than two years CLS Bank entered live operations in September 2002. Table 4.2 summarizes the key milestones of the CLS history.

Date	Event
Oct 1994	**Formation of the G20**
Dec 1994	Proposition of 3 different models
May 1995	Cancelation of model 1
Aug 1995	Going live of ECHO
Nov 1995	Estimated project costs: USD 60 mio.
Feb 1996	Approval of model 3, first meetings with Net Systems
Mar 1996	Basic questionnaire regarding choice of jurisdiction, start of BRS phase
Oct 1996	Generic framework for business case completed
Dec 1996	Legal issues regarding Switzerland: first report by Niederer Kraft & Frey
Jan 1997	Detailed legal survey of possible jurisdictions
Feb 1997	Approval of BRS, setting membership criteria
Apr 1997	Decision to form a legal entity, estimated project costs: USD 80 mio.
Jul 1997	**Incorporation of CLS Services Ltd.**
Oct 1997	Sending request for proposal to potential vendors
Dec 1997	**Merger of Net Systems with CLS**
Mar 1998	Discussions regarding remote access to RTGS of relevant central banks completed
Apr 1998	**IBM becomes prime contractor**
Jun 1998	Estimated project costs: USD 130 mio.
Jul 1998	Signing of IBM contracts going live target is July 2000 Decision to liquidate Multinet
Aug 1998	Recapitalization successful
Nov 1998	IBM resumes contract discussions due to complexity of FRS

continued on next page

Date	**Event**
Jan 1999	CLS accepts a delay of 70 days, go live target is Oct 2000
Feb 1999	Board recommends to suspend ECHO
Apr 1999	**Closing of ECHO**, core programming of CLS completed
Jun 1999	First phase of system testing with 4 beta banks
Aug 1999	Application for banking licence at FED
Nov 1999	**Banking licence, formation of CLS Bank**
Mar 2000	Legal issues in Switzerland: second report by Niederer Kraft & Frey Rescheduling of going live to Sept 2001
Apr 2000	Estimated project costs: USD 300 mio.
May 2000	**Final dissolving of Multinet**
Jun 2000	Second recapitalization successful
Dec 2000	IBM asks for further delays, CLS insists on timely delivery of a first release
Jun 2001	**Corporate restructuring**: formation of a holding company in Switzerland Communication of further delays
Nov 2001	IBM again suggests revision of time line, CLS negotiates 100 percent cost cover
Jan 2002	Redefining IBM's milestones
Aug 2002	Interface errors, delay of another 4 weeks
Sep 2002	**Going live**
Dec 2002	Signing of new IBM service agreements with cost increases of 30 percent
Mar 2003	Only severe service disruption
Jul 2003	10 percent settlement price increase

Table 4.2: Milestones of CLS's History.

Chapter 5

Design of CLS

To provide insight into different aspects of the company and its processes as of today, this chapter describes CLS as a legal entity as well as the design of the system. The chapter starts off with an overview of CLS as a legal entity and its members, followed by a technical description of the settlement process. The paragraphs of the section explaining the CLS system's mechanism, are organized according to the original director's manual (CLS 2004*c*). The remaining sections discuss two specific issues that need particular attention, the risk management framework and the liquidity management.

5.1 CLS as a Bank

The CLS entity is set up as a limited purpose bank that provides simultaneous multi-currency real-time gross settlement with finality. CLS holds accounts with the central banks of each eligible currency and is directly connected to each respective domestic RTGS system. Banking status is necessary in order for some central banks to allow CLS Bank to hold accounts with them.

5.1.1 Corporate Structure

Settlement members and user members (see 5.2) are the shareholders of the CLS Bank. Prior to the year 2000, CLS Bank was named CLS Services Ltd. and was incorporated in the United Kingdom with a subsidiary called CLS Operations. With the receipt of a banking licence in 1999 (see 4.3.1), a second subsidiary with the name CLS Bank International was established in the United States. To create a robust governance structure and provide a clean solution for tax purposes, CLS Services Ltd., the former UK company, became a shell company and changed its name to CLS UK Holdings

Ltd. The operational subsidiary was now named CLS Services. At the same time and for the same reasons a holding company domiciled in Switzerland was introduced. The Swiss CLS Group Holdings AG is today regulated by the Federal Reserve in the United States as a bank holding company. The two subsidiaries, CLS Bank International in New York and CLS Services in London manage the operations (see figure 5.1) (CLS 2004*a*).

5.1.2 Corporate Governance

The CLS Group Holdings board comprises 26 directors of which at most 3 directors hold a senior executive position. One director is the Swiss based company secretary and the remaining 22 directors are composed of non-executive shareholder representatives (see figure 5.1). They are selected based on eligibility criteria such as the shareholders financial contribution to the CLS Bank and their individual quality. The main function of the Group Holdings board is to provide ultimate direction and supervision, control and business oversight. It is setting the guidelines for the general policy and strategy of the company and ensuring appropriate communication to its shareholders (CLS 2004*a*). The Executive Committee, the Nominating & Governance Committee, and the Audit Committee are three subsets of the CLS Group Holdings board. The Executive Committee includes the CEO of the CLS Group Holdings as well as seven non-executive directors. It provides a vehicle for rapid response regarding issues that require endorsement on the board level. The Nominating & Governance Committee also consists of seven non-executive directors and the CEO of the CLS Group Holdings. The committee assures proper governance of the CLS Group and makes recommendations to the board regarding new directors of the board, subsidiary boards and the different committees. The Audit Committee encompasses eight non-executive directors of which at least one has relevant up-to-date financial experience. The committee ensures compliance of internal control systems with applicable company law and current regulatory frameworks. It monitors the integrity of the financial statements and manages the relationship with the external auditor (CLS 2004*a*). Due to its function as a shell company CLS UK Holdings Ltd. only includes two executive directors. The management of CLS Bank International is based in New York. The board of CLS Bank International includes ten non-executive directors and 2 executive directors. The Risk Management Committee includes up to ten non-executive members and the Executive Vice President of Risk Management and Regulatory Affairs. The committee's role is to continuously evaluate the effectiveness of the risk management policies and practices and to provide advice and counsel in this regard (CLS 2004*a*). CLS Services's

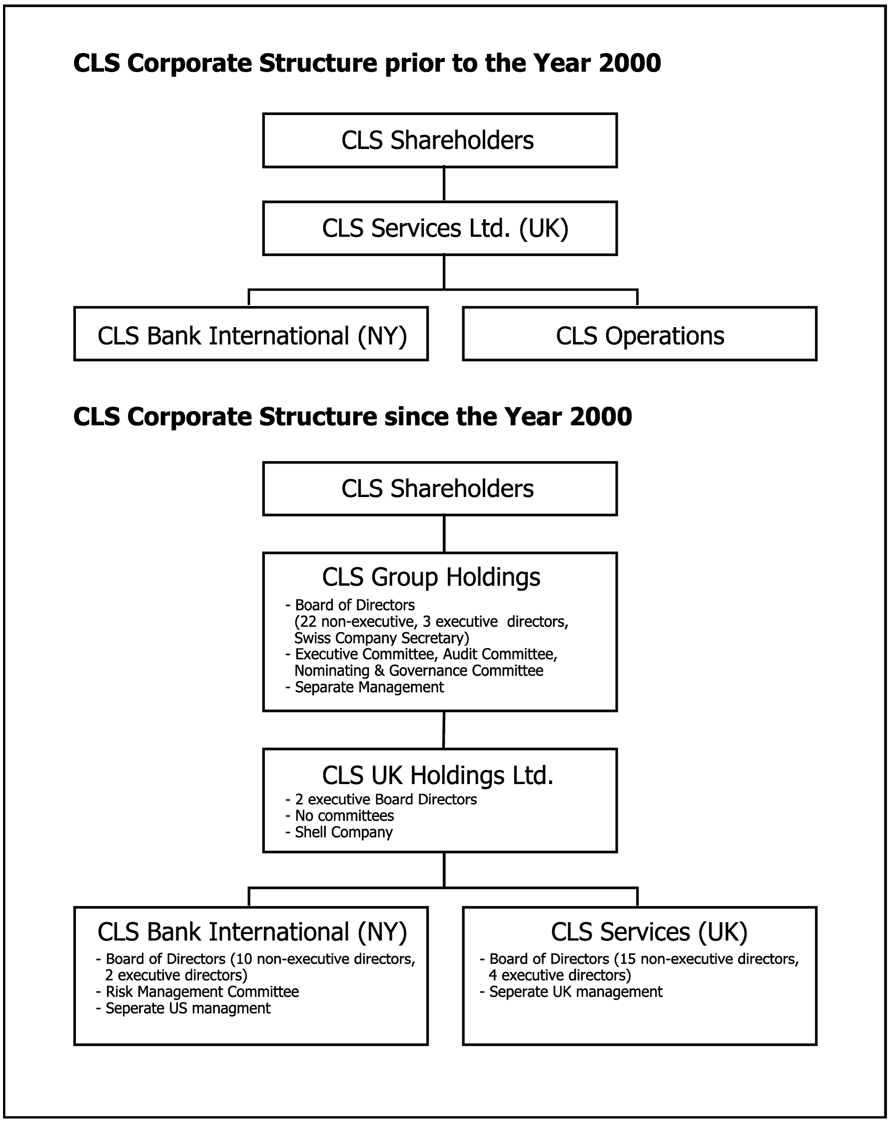

Figure 5.1: CLS Corporate Structure (CLS 2004*b*).

board of directors consists of 15 non-executive and four executive directors. Until 2003 the Operations and Implementations Committee was affiliated to CLS Services. The committee's objective was to provide advice and support to the Board of CLS Services regarding service operation, system implementation and the planning for customer service support (CLS 2003*b*). Since 2004 the Operations and Implementations Committee is integrated into the CLS Services's board. From a business perspective, CLS's governance structure is designed to enable consistent and effective shareholder influence over the group and in particular CLS Bank. The possible overlap of CLS Group Holdings and CLS Bank board of directors is supposed to allow flexible governance arrangements (CLS 2004*b*).

5.2 Membership

CLS Bank offers two different membership options and one user only option: settlement members, user members, and third party users. Banks acting as nostro agents are not members of CLS but still involved in the payment flows between CLS and its members (see figure 5.2). All members must fulfill certain criteria such as being a shareholder of CLS, being a qualified financial institution, adhering to defined measures to combat money laundering, demonstrating sufficient operational capability and meeting minimum financial and credit requirements (CLS 2004*b*)(see also 4.1.2). The different membership options are described in the following sections.

5.2.1 Settlement Members

Settlement members are banks, trust companies or broker-dealers under supervision of an authority that is acceptable to CLS Bank. They can submit settlement instructions for themselves, as nostro agents, and for their customers directly to CLS Bank. Each settlement member has a single multi-currency account with CLS Bank. To connect to the CLS core system, members must use a CLS gateway. To do so, settlement members as well as user members are required to become users of SWIFTNet InterAct[1]. As of 2006, CLS encompasses 54 settlement members. All settlement members are also shareholders of CLS Bank. The total number of Shareholders, however, amounts to 71 at the beginning of 2007.

[1]SWIFTNet InterAct is a messaging service that supports the exchange of automated and interactive messages between two parties (see also 2.5.16).

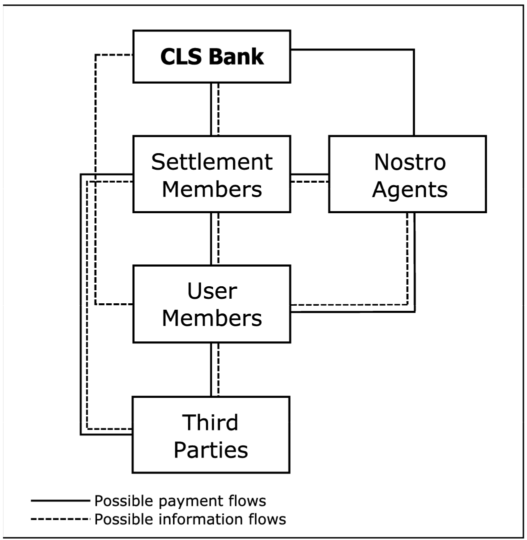

Figure 5.2: Participants of the CLS System (CLS 2006).

5.2.2 User Members

The category of user members had been created to address the pressure from smaller banks and especially from broker/dealers that would either not meet the eligibility criteria for settlement membership or were not involved in settlement at all. A third party solution was not considered by the broker/dealer shareholder as in the position of such they would have had to disclose their trading strategy to the settlement member in order to get the instructions settled. Confidentiality of trades would have been lost. Therefore, a third party solution was out of question and a settlement membership with all its consequences such as the timed pay-ins (see 5.4.4) unwanted. For this reason and to address the central bank's concern for open and fair access for participation, the user member status was created (CLS 1998*a*). Today, however, there is only one bank with status of a user member. User members are also shareholders of CLS Bank and may submit transactions for settlement, including transactions for third parties, directly to CLS on the trade day. However, user members cannot settle transactions in their own name within CLS nor have a separate account. Instead a transaction submitted by a user member must be settled through a designated settlement member, who will assume responsibility, as principal, for settlement of the transaction and for fulfilling all funding obligations. The user member does not receive CLS pay-in schedules (see 5.4.4), but has its own payment schedule agreed with its settlement member. Hence, the principal distinction between a user member and a settlement member is that the relationship of the user member to CLS bank is solely operational in nature. The user member does not assume responsibility for settlement and liquidity risk.

5.2.3 Third Parties

Using the CLS system, settlement members and user members can supply third parties with integrated multi-currency foreign exchange settlement services with minimal settlement risk. In that, third parties are defined as any parties involved in foreign exchange trading, who are not CLS members. At the beginning of 2007, the number of third parties exceeded 900. Third party services, however, are only offered by about 18 settlement members. Third parties have no contractual relationship nor any other direct relation to CLS. It is necessary for a third party to submit both, the pay and the receive leg of each individual transaction through the same CLS member. Otherwise, the transaction would not be self collateralized.

5.2.4 Nostro Agents

Settlement members send their pay-in instructions directly to CLS if they are connected to the local RTGS of the respective currency. Otherwise the service of a nostro agent is necessary. However, to act as a nostro agent for a CLS member no contractual relation to CLS is needed. The nostro agent only needs to be connected to the respective local RTGS to transfer the pay-ins to CLS in lieu of the settlement member.

5.3 Eligible Currencies

In September 2002, CLS went live with 7 currencies: United States dollar, Australian dollar, Canadian dollar, Euro, Japanese yen, Swiss franc and UK Pound sterling. During 2003 the currencies of Norway, Sweden, Denmark and Singapore were enclosed, followed by the currencies of Korea, South Africa, Hong Kong, and New Zealnd in 2004 (CLS 2003*e*). Today, CLS Bank settles in 15 currencies (see also 2.5). Currencies may be designated as eligible by the board of directors if they satisfy the following criteria:

1. At least two CLS shareholders have requested the eligibility of that currency.

2. There are at least three commercially acceptable institutions that have indicated their willingness to act as liquidity providers (see 5.5.2) for this currency.

3. The relevant payment system meets the requirements of CLS including opening hours that sufficiently overlap with the settlement period for all eligible currencies.

4. The cost to include the currency are deemed reasonable.

5. An adequate risk reduction results from its inclusion to justify the necessary investments.

6. Any exchange restrictions or similar conditions on the transferability as well as convertibility, liquidity and historical volatility are acceptable to CLS Bank.

7. The relevant central bank has agreed to establish a special account for CLS Bank to facilitate the transfer of the currency from and to settlement members.

8. CLS Bank has received a legal opinion addressing finality of payments made to and from CLS Bank's account with the relevant central bank.

5.4 Settlement and Funding

To address the risk associated with settling foreign exchange transactions, CLS ensures the continuous and simultaneous settlement of linked currency exchanges. Actual settlement processing is executed during a five-hour window when all relevant RTGS systems are open to send and receive funds. For Asia Pacific currencies the window is limited to only four hours. During this time, matched transactions are selected one at a time and are subject to the risk management tests. After having passed the tests, settlement becomes irrevocable and is effected immediately with finality, through the posting of debits and credits of the settlement member's accounts on the books of CLS. Settlement members are required to pay in funds into their CLS bank accounts to cover short currency positions according to a pay-in schedule issued by CLS to its members. At the end of the settlement day all long balances are disbursed to the settlement members. The following sections lead in detail through this settlement process (CLS 2004*c*).

5.4.1 Settlement versus Funding

CLS Bank maintains one account for each settlement member and one account for each currency with the relevant central bank. The design of the service draws a clear distinction between settlement instructions and pay-in instructions. Settlement instructions trigger settlement on a gross basis between members, while pay-in instructions release the funds that need to be sent from a member to CLS. The necessary pay-ins are calculated on a net basis. Combined it may be summarized as gross settlement with net funding. Although settlement and funding are legally separate processes, the two processes are linked and run operationally in parallel. Settlement occurs when CLS Bank simultaneously debits and credits the account of two settlement members in accordance with eligible settlement instructions that were submitted by the settlement members (or by user members and authorized by settlement members acting as their designated agent). The transaction is final and binding for both involved members. Funding is the process by which a settlement member (or its nostro agent) transfers eligible currencies into CLS Bank's central bank accounts. CLS Bank is notified of the receipt and credits the settlement member's account. The pay-in is completed. To process pay-outs, CLS Bank disburses funds from its central bank account to a settlement member (or its nostro agent) and debits its account accordingly.

5.4.2 Submission and Initial Processing of Instructions

Settlement instructions direct CLS Bank to settle certain obligations and entitlements to receive payments arising pursuant to a single, specifically identified, foreign exchange transaction. The instructions are submitted by members using specific SWIFT messages sent via SWIFTNet to CLS Services. Each instruction must clearly identify both, the member sending it and the member that is expected to submit an instruction with respect to the same transaction. Further, it specifies the exchange rate, the amounts, and the identities of the currencies to be delivered and received pursuant to the instruction, as well as the date on which the instruction is scheduled for settlement in CLS Bank (the value date) and the two counterparties to the underlying foreign exchange transaction. In general, members may submit instructions for settlement from the time the foreign exchange transaction is executed, up to approximately 06:30 CET on the value date specified in the instruction. From a risk perspective a prompt submittance of settlement instructions after a trade is desired. Possible misunderstandings at contract closure (trading often takes place via phone calls) may not be detected until matching. Hence, as sooner as matching occurs after a trade the shorter the period until contract errors are noticed. A member that wants to amend or rescind previously submitted settlement instructions must send an amend or rescind instruction prior to the applicable deadlines on the value date (see 5.4.3). Once a settlement instruction has been properly authenticated, it is subject to further processing and validation. When an instruction is received at CLS, the submitting member is notified of the status of that instruction. An instruction can be classified as either rejected (e.g. when it is recognized as a potential duplicate instruction), invalid (e.g. members or currencies that are suspended or value dates that are not banking days), suspended (e.g. when it fails to pass certain filters) or unmatched (see figure 5.3).

5.4.3 Matching

CLS Services matches a pair of validated settlement instructions based on the following information contained in each instruction: (1) identification codes of members submitting the instruction relating to the same transaction, (2)the value date, (3) the amounts and identities of the buy and sell currencies, and (4) the identification codes of the two counterparties of the underlying foreign exchange transaction. As mentioned before, settlement instructions may be submitted up to the release of the final pay-in schedule at about 06:30 CET. Each pair of settlement instructions that can be matched is designated as matched instruction, and the relevant members are notified of this new status. An instruction that has not been matched is held in the CLS system until the settlement process for the relevant currency has been completed on its value date. At this time, the instruction is rejected. Matched instructions can unilaterally be rescinded or amended by members at any time prior to the initial pay-in schedule deadline for that instruction's value date which is at 00:00 CET. Bilaterally, matched instructions may be rescinded up to the final pay-in schedule approximately at 06:30 CET. Unmatched instructions that have not been rejected by the CLS system may unilaterally be rescinded or amended up to the final pay-in schedule. As soon as a pair of instructions is matched CLS Services determines whether it is eligible for settlement. Matched instructions submitted by two settlement members are automatically designated as settlement eligible instructions. If at least one user member is involved, it is verified that each settlement member identified in the matched instructions is approved by the other. Settlement members approving each other allows them to manage their exposures to each other arising from instructions that involve user members. After an instruction submitted by a user member is classified as eligible for settlement, it will not be processed until it is authorized by the

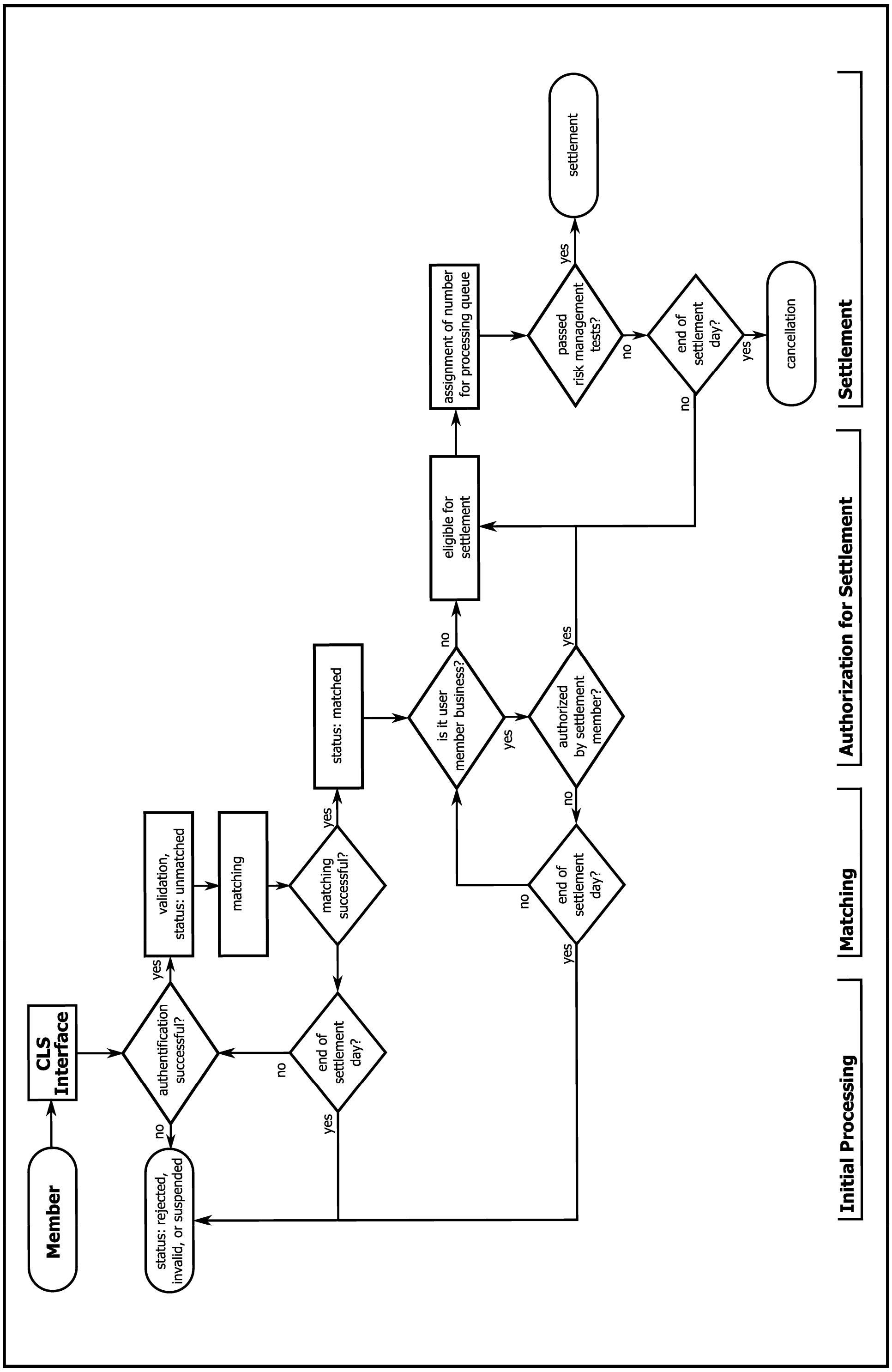

Figure 5.3: Simplified Instruction Flow (author).

applicable settlement member. Usually authorization is targeted to occur approximately between 22:00 and 00:00 CET on the day prior to the value date and approximately between 00:00 and 06:30 CET on value date for same-day instructions. Figure 5.3 summarizes this process.

5.4.4 Pay-In Schedules

The pay-in schedule contains CLS Bank's projection of the amounts that a settlement member must pay to and expects to receive from CLS Bank if all settlement eligible instructions scheduled to be processed that business day do in fact settle. Due to its function as a continuous linked settlement facility settling currencies in different time zones, funding in CLS significantly differs from other market practices. Minimum installments of the total net pay-in obligation in each currency must be made by specified times on each settlement day. Thus, the pay-in schedule not only defines the total amount of each currency that a settlement member must pay to CLS Bank during a day, but also the times on or before which such amounts must be paid in. Each settlement member must be operationally capable of meeting, either directly or through a financial institution that acts as its nostro agent (see 5.2.4), the pay-in requirements. The schedule is structured to ensure that settlement is completed by the target time of approximately 09:00 CET and that pay-outs of the Asian-Pacific currencies are made prior to the closing of their local payment system at about 10:30 CET. To accomplish this, CLS Bank accelerates the pay-in schedules to ensure that sufficient amounts are paid in by 09:00 CET and all settlement members are within their short position limits (see 5.5.1) to complete settlement on time on 09:00 CET. The several hour funding period makes the best use of the overlapping opening hours of the local payment systems in the different time zones and facilitates liquidity management by allowing settlement members to spread their pay-ins at least across these hours. Late pay-ins are penalized by CLS Bank. For each value date, two pay-in schedules are issued. The initial pay-in schedule is generated at about 00:00 CET and shows the expected net pay-in requirements and the pay-outs resulting from the settlement eligible instructions so far. After 06:30 CET no further instructions will be classified as eligible for settlement for that day and no instructions can be rescinded by any member (see 5.4.3). Once this cut-off time has passed, CLS Bank delivers the second pay-in schedule. The second schedule may differ from the initial one due to inclusion of same-day instructions designated as eligible for settlement between 00:00 CET and the cut-off at 06:30 CET or bilaterally rescinded instructions. Upon receipt of its pay-in schedule, settlement members acknowledge it to CLS Bank and subsequently instruct their payment departments to transfer funds to their respective accounts at CLS Bank in accordance with their schedules.

5.4.5 Queue Formation and Splitting Process

CLS Bank processes instructions for settlement on any day on which the local payment systems for at least two eligible currencies are in operation. Prior to the start of the actual settlement, a processing queue is formed that contains all settlement eligible instructions for that particular value date. When the initial pay-in schedule is generated, those instructions that have been classified as eligible for settlement, including those that are the result of the splitting process (see below), will be assigned a random sequence number. Each instruction is subsequently placed on the settlement processing queue in accordance with this assigned sequence number. Modelling studies had indicated that in the event of a pay-in failure by a settlement member, instructions split into amounts below short position limits (see p. 86) may limit the effect of unsettled instructions on that value date. If instructions are not split, the largest ones that need the most liquidity tend to be the last settled and this occurs closest to the completion target time. In addition, if the amount of the instruction is greater than the currency's short position limit, a pay-in failure could cause the entire position to remain unsettled even though the short position limit would permit part of the instruction to settle. For example, if the short position limit for a currency is USD 1 billion and the size of an instruction is USD 1.5 billion, a pay-in failure could result in the entire USD 1.5 billion to remain unsettled. This could have a significant knock-on effect for other settlement members. By splitting this instruction into smaller components, approximately USD 1 billion of the original USD 1.5 billion could be settled within the short position limit (provided the account has sufficient overall value). To facilitate earlier settlement and to minimize the magnitude of the effect of unsettled instructions, the CLS system established splitting thresholds. For Euro transactions for instance, the current threshold is set at 150 million for one instruction (CLS 2004*d*). When the initial pay-in schedule is generated at about 00:00 CET, each settlement eligible instruction is tested against currency splitting threshold values and if applicable, the instruction is split in two or more separate instructions. The period for processing same-day instructions occurs between 00:00 and 06:30 CET. Within this period of time, CLS Bank opens so called same-day gateways during which same-day instructions are placed on the settlement processing queue. Whenever a same-day gateway is opened, each same-day instruction is also tested against the currency splitting threshold values and split in two or more instructions if applicable. These instructions, includ-

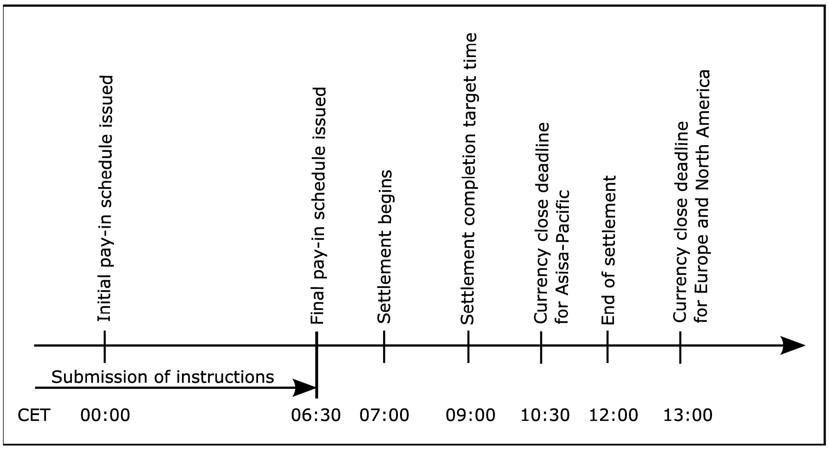

Figure 5.4: Time Line of Settlement Process (CLS 2006).

ing those that result from the splitting process, are assigned a sequential number that is larger than the largest random sequence number. Thus, the settlement processing queue consists of all instructions that are classified as settlement eligible prior to the calculation of the initial pay-in schedule in random order, followed by all same-day instructions entered to the system after the calculation of the first pay-in schedule in sequential order.

5.4.6 Settlement

To execute the pay-ins and pay-outs, the involved local payment systems of all involved countries must offer overlapping opening hours. The commencement of the settlement period is therefore set to 07:00 CET (see figure 5.4). Settlement processing begins by selecting the first matched transaction in the queue. The system tests the two counterparties of the transaction against the three risk management criteria Net Positive Overall Value, Short Position Limit and Aggregate Short Position Limit (see 5.5). If the transaction passes the tests, then it is settled immediately through the posting of debit and credits to the member's accounts on the books of CLS. The settled transaction is irrevocable and final. If the transaction selected for settlement fails the risk management tests, it is returned to the settlement processing queue (see figure 5.3). CLS settlement is complete when all transactions have left the settlement processing queue and have been settled or rescinded. The target time for settlement completion is 09:00 CET. Funding lasts until 12:00 CET. In order to be in a position to fulfill its obligations to make pay-outs of long positions to eligible settlement members on a same-day basis, CLS Bank must complete funding in each currency before the relevant local payment system closes. CLS will process funding until the so called currency close deadline which is at approximately 10:30 CET for Asian-Pacific currencies and 13:00 for European and North American currencies. If not all instructions involving Asia-Pacific currencies are settled by the currency close deadline, CLS Bank will no longer attempt to settle those instructions as their local payment system closing time approaches. Since more time remains before the closing of the European and North America payment systems, CLS Bank attempts to settle instructions not involving Asian-Pacific currencies past the currency close deadline for Asian-Pacific currencies. After 12:00 CET, however, unsettled instructions are removed from the queue and the affected members have to decide whether to resubmit the instruction for settlement processing the next business day or to settle the underlying foreign exchange transaction outside CLS Bank and manage the arising settlement exposure.

5.4.7 Pay-Outs

CLS Bank is obligated to pay-out long positions to settlement members. In order to minimize the liquidity impact on the local markets, CLS Bank seeks, within the constraints of the risk parameters, to make pay-outs throughout the settlement process. Under normal circumstance, where settlement is successfully completed, CLS Bank pays out any long balances in its central bank accounts to the settlement members before the closing of the respective payment systems. As a result, a settlement member has a zero balance in its CLS account and CLS Bank has no funds in its central bank accounts at the end of each business day.

5.5 Risk Management Framework

A risk management framework has been elaborated in order to achieve continuous stability and integrity of the CLS settlement process. The main principles of the framework include the protection of principal losses and irrevocability of transferred funds. All operational risks are borne by the members and not by CLS Bank. Neither liquidity providers (see 5.5.2) nor central banks should bear incremental, unsecured risk. The framework is built on three main pillars: Overdraft facilities, liquidity providers, and loss sharing arrangements.

5.5.1 Overdraft Facilities

To support the efficiency of the settlement process but still to control the risk of a liquidity shortfall due to a failing member, the following three risk management tests are applied to each transaction in the settlement processing queue on the respective settlement day: (1) Net Positive Overall Value, (2) Short Position Limit, and (3) Aggregate Short Position Limit. Transactions will only be marked eligible to settle if they have successfully passed these risk management requirements. The rules also apply to the pay-outs of long positions after the completion of settlement.

Net Positive Overall Value

This risk management rule ensures self collateralization in that each member maintains a Net Positive Overall Value (NPOV) across its accounts at CLS Bank. A NPOV is met when the mark-to-market value of the member's aggregated long currency position is more than the aggregate of the mark-to-market values of its short positions. The currency positions are continuously marked to market and assessed in US dollar equivalents provided by Reuters. Furthermore the mark-to-market will always include a haircut. Haircuts are used as a risk management tool to protect against exchange rate volatility when evaluating a settlement member's account balance. CLS Bank sets an individual haircut level for each currency. It is based on a volatility calculation for a 6 day holding period and four standard deviations as well as a variable 5 percent add-on. Depending on market volatility, the add-on percentage may be increased with the approval of the Risk Management Committee and the CLS Bank board of directors. The haircut reduces the positive value of long positions and increases the negative value of short positions. It is designed to provide an adequate cushion to manage through a crisis rather than covering risk in normal operation. As settlement members do not put up separate collateral to cover their market risk exposures, haircut levels can be seen as a form of intra-day collateral. It ensures that CLS Bank disposes of sufficient counter currency to acquire needed liquidity through a transaction with a liquidity provider and hence, minimizes the risk of other settlement members being assessed a loss allocation (CLS 2004*d*). If mark-to-market variations and applied haircuts change a member's overall balance resulting in a negative overall value, the member is asked to accelerate its pay-in schedule or place immediate cash deposits in any eligible currency. In the meantime all transactions involving this particular member are set on hold. As en example for a net positive overall value table 5.1 displays the assumed mark-to-market positions (after applied haircuts) for a particular settlement

Multi-Currency Account
in USD Equivalents

	debit	credit
CHF	200 300	500
	500	500
USD	200 100	300
	300	300
GBP	700	200 500
	700	700
Aggregated	1’100	1’000 100
	1’100	**1’100**

Table 5.1: Example of NPOV.

member. Even though the settlement member is short in its mark-to-market positions of CHF and USD, its account shows a long position in GBP which results in a net positive overall value. The positions in this example look as follows:

- short position in CHF = 300 USD
- short position in USD = 100 USD
- long position in GBP = 500 USD
- aggregated short position = 400 USD
- **net overall value = 100 USD**

Short Position Limit

Each settlement member’s short currency position is constrained within the member’s short position limit (SPL) for a particular currency. During bank holidays the SPL is set to zero for the affected currency as the domestic payment system for that currency is closed. This risk management rule limits the size of a potential liquidity shortfall in a particular currency and ensures that the amount can be covered by liquidity providers (see 5.5.2). The maximum SPL for a given currency is the same for all members and is a function of the committed liquidity in that currency. Thus, the maximum SPL for a single member allows for the failure of the single largest liquidity provider. As required by the Lamfalussy-standards (see 3.3.2) this enables CLS to duly complete any settlement day even if the failing member is a liquidity provider and shows the largest net-debit position. In contrast to the required net positive overall value that manages credit risk aspects regarding the failure of a member (self collateralization), the short position limit reduces liquidity risk arising from failed pay-ins. It assures that even in case of a failing member the right currencies can be paid out to the other members. To improve settlement efficiency there is also a minimum SPL which is derived from modelling the CLS process. Referring to the example on page 86 each of the currencies has its own short position limit. In this example for instance, the SPL for Swiss francs is at least equivalent to 300 USD as each member must lie within the SPL of each currency at any time.

Aggregate Short Position Limit

The aggregate short position limit (ASPL) places a cap on the sum of a member's short positions to contain a potential liquidity shortfall across all currencies in case of a member's failure. A member's aggregated short position is represented by the sum of its currency short positions marked-to-market valued continuously in US dollar equivalent and applied haircuts. The example on page 86 results in an aggregate short position of 400 USD. The ASPL is related to the level of the member's capital and CLS internal credit rating. An example of how an ASPL is established for a settlement member is set forth in the following. Note that figures for this example are assumed for illustrative purposes. Bank A applies to CLS Bank for settlement membership. The applicant has a current tier 1 capital of USD 8.5 billion equivalent and an internal short term credit rating of A1. CLS Bank defines four internal short term credit ratings: A1+, A1, A2, and A3. This level of capital and credit rating is defined to correspond to an equity factor of 80 percent and a credit risk factor of 90 percent. These factors, applied to a maximum aggregate short position limit of USD 1.5 billion, lead to a suggested aggregate short position limit of USD 1.08 billion for Bank A. The short position limit for any currency, however, is the same as for any other settlement member.

5.5.2 Liquidity Providers

CLS Bank has established liquidity providers to limit the impact of a payment default by a member. Liquidity providers are banks that commit to provide liquidity in a certain currency in case other members fail to meet their pay-ins in that particular currency. There are at least three liquidity providers for each currency. It is assumed that the shortfall is of temporary nature and the arrangement is basically set up as an overnight foreign exchange swap. This means that CLS Bank sells parts of the positive balances off the defaulting member's sub-accounts to the liquidity providers who in turn provide the missing amount in the particular currency. The transaction is supposed to reverse the next day. However, CLS Bank has established a risk model for liquidity providers to assure the repayment in any kind of scenario. The risk model is designed to provide three stages of repayment (CLS 2003*g*):

1. In the most basic case the failing member recovers and pays in the short funds.

2. If the member does not recover, CLS Bank will execute an outright transaction based on the long positions of the failing member's sub-accounts. To do so CLS Bank will access the funds at its central bank accounts which come from that day's pay-ins. The haircuts applied to the aggregate short position limit ensure an adequate coverage at all times.

3. Should arrangement 1 or 2 not provide the necessary funds, CLS Bank is able to initially allocate the losses to those settlement members that had traded with the failing member. If even that proves insufficient, a general loss allocation will be invoked (see 5.5.3).

Figure 5.5 illustrates an example. A particular settlement member is unable to meet its pay-in obligations in EUR (1) but is long in Yen. CLS accesses the failing member's central bank account containing the Yen position (2) and enters an overnight EUR/Yen swap with the euro liquidity provider (3) to receive the missing EUR to pay them out to the other member that expect a EUR pay-out (4). If the failing member recovers the next day, the swap is reversed. Otherwise the swap is transformed into an outright purchase and the liquidity provider does not retrieve its EUR but must keep the Yen position. In case it is not possible to execute an outright purchase or the funds are not sufficient, CLS will introduce a loss sharing arrangement (see 5.5.3). The aggregated commitments of the liquidity providers in a particular currency are large enough to cover a shortfall even in a worst case scenario. In case of a default by the most important liquidity provider in

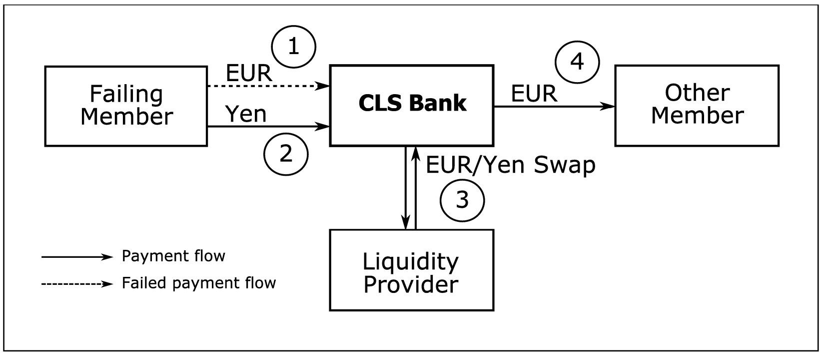

Figure 5.5: Liquidity Provider Transaction (author).

each currency the remaining liquidity providers of that particular currency are still able to cover the short balance. Up to date, it was not necessary to make use of the liquidity provider facility at all.

5.5.3 Loss Sharing Arrangements

Despite the liquidity facilities described in the previous section, exceptional circumstances might still cause losses to CLS Bank. Losses may be caused for two main reasons. First, an adverse change in foreign exchange rates eroding the haircuts keeps CLS Bank from being able to complete the transaction with the liquidity provider. If for instance the variation in one or more currencies exceeds the volatility haircuts in those currencies, the balances of a failing member's sub-accounts might turn negative. CLS Bank would then not have sufficient funds to swap transactions with the liquidity providers. Second, the liquidity provider with whom CLS Bank has entered the swap is unable or unwilling to provide quotes for an outright purchase. The swap might then be rolled over for up to 4 banking days on a one day "today/tomorrow" basis (CLS 2003*a*). However, if the time for rolling over the swap ends, or CLS bank decides there is no point in continuing to roll it over and an outright transaction is still not possible, CLS Bank will have to perform a loss allocation to raise enough of the particular currency to complete the swap (CLS 2003*f*). To do this, CLS Bank will use the pay-ins of its settlement members. Prior to the combined loss allocation CLS Bank will perform a failure adjustment in which it debits the failing member's sub-accounts for all amounts due. The resulting negative account balance of the failing member will be subject to a loss allocation. There is a systematic allocation scheme which starts off by a combined loss allocation. It is a pro rata allocation of the losses to members who had dealt with the defaulting member. The total loss borne by a particular settlement member is thus capped by the bilateral net amount traded with the failing member. If this does not raise enough funds to cover the shortfall, it will be subject to a general loss allocation in which the outstanding losses are shared among all surviving members (the general loss allocation is subject to a USD 30 million cap). As soon as the necessary funds are raised by CLS Bank it completes the swap with the liquidity provider. CLS Bank now endeavors to liquidate the received currency in the market and to collect the amount of the negative account balance from the failing member with interest. The proceeds from this process are redistributed pro rata to the settlement members that covered the loss (CLS 2003*f*). Hence, the loss sharing arrangement is only applied in circumstances where other risk management rules have been inadequate and could not cover the short positions of the failing member.

5.6 Liquidity Management Framework

Payment systems operate on a single currency basis and execute instructions during the normal business hours of the locations of the currencies in question. In nearly all instances, payments have to be made by the end of the payment system day. CLS funding flows, however, are fundamentally different for two reasons. First, payments are made on a net basis and second, they are time critical. For USD and CAD, CLS clearing is completed before normal clearing begins. Making large pay-ins to CLS can be a cost and credit issue because covering funds are only received much later that day. For the European currencies, CLS and normal clearing happens at roughly similar times. However, an institution with large CLS short positions may have difficulties at the start of the day due to front-loading of the pay-in schedule. For Asia-Pacific currencies, normal clearing is completed before CLS clearing begins. An institution expecting to receive a large CLS pay-out very late in the day is likely to build up a significant debit position in the domestic payment system prior to the CLS pay-out (CLS 2002*i*). These issues were identified before the going-live of the system. In 1999, a European G20 bank explicitly addressed one of these time lag problems between currency cash flows of CLS Bank requirements and flows of other settlement systems. An example of such a mismatch is the timing of USD settlement between CLS Bank requirements and CHIPS, when combined with SIC settlement in CHF (for explanations regarding CHIPS and SIC see 2.5). If a CLS settlement member enters into a foreign exchange swap between CHF and USD in order to transfer a long CHF cash position into USD, and invest the resulting USD in a Money Market instrument settling in CHIPS, settlement takes place as follows:

- Day one:

  Sale of CHF and purchase of USD

  Purchase of USD Money Market instrument

- Day two:

  Maturity of USD Money Market instrument

  Sale of USD and purchase of CHF

The two foreign exchange trades are settled in CLS, while the Money Market trade settles at CHIPS. Therefore on day one, the first leg of the foreign exchange swap will require a CLS pay-in of CHF during 07:00-12:00 CET. USD will be provided at the same time (01:00-06:00 Eastern Standard Time (EST)). The Money Market trade settling at CHIPS will require the USD pay-in at Fedwire by 24:00 CET (18:00 EST). On day two, the maturing leg of the foreign exchange swap again settles in CLS and requires a Fedwire pay-in between 01:00-06:00 EST. CHF will be released through SIC simultaneously between 07:00-12:00 CET. However, the payment resulting from the maturing Money Market trade settling in CHIPS will only be available at 18:00 EST (24:00 CET). As a result, the settlement member is long in USD on day one for half a day and short on day two for a similar period. Hence, even though a member might close its trading day with a balanced currency position (and therefore with no net liquidity needs), large pay-ins to CLS might be required because of onesided CLS trades. In other words, net liquidity needs might be zero for the day if all currency transactions are included in the calculation but looking only at CLS trades, large pay-ins might be due during the morning hours of CET generating a net liquidity need during the day. This imparity of CLS trades and non-CLS trades can be eased by the mechanism of in-out swaps (CLS 1999*f*).

5.6.1 In-Out Swaps

Given the complexity of the liquidity management it was agreed that an appropriate tool is necessary to support the settlement members in managing their liquidity imbalances that result from having only a sub-set of their foreign exchange counterparties settling their payment instructions through CLS. An in-out swap working group was formed in February 2000 to turn in-out swaps into reality. The in-out swap consists of two foreign exchange transactions which are equal and opposite. Both are agreed at the same time as part of a single swap. They modify the required intra-day cash flows, thereby leaving the settlement members' foreign exchange positions unchanged. In-out swaps recognize that an institution with a large short position in one CLS currency almost certainly has a large long position of another currency in CLS. The swap reduces these in-CLS cash positions, as well as corresponding liquidity positions outside CLS (CLS 2002*i*). At the end of 2000 the board reluctantly approved CLS's role as calculation agent for in-out swaps. This service was regarded as a tactical solution in the interim and not as a long-term instrument. Participation of member in in-out swaps was never mandatory and it remained a strategic objective to find better solutions for liquidity management. Although regulators did not like the reintroduction of Herstatt risk, they tolerated it at that moment (CLS 2000*b*). From a total risk management point of view the reduction of liquidity risk was considered more valuable than the abandonment of reintroducing a small amount of Herstatt risk. Up until now, the in-out swap has evolved into an integral part of CLS operations (Credit Suisse 2004).

The Mechanism of In-Out Swaps

The in-out swap mechanism involves one foreign exchange trade settled via CLS Bank in which they sell long positions and buy short positions and one trade settled outside CLS Bank which is an exact mirror image of the inside transaction. The point is to relieve time and liquidity pressure as the outside transaction, unlike the CLS transaction, does not need to match a specific timing. While the inside transaction reduces the necessary pay-ins, the outside transaction may be settled at any time during the day of the local payment system. With this mechanism some credit risk is reintroduced due to the outside leg (Sawyer 2004). This of course contradicts the goal of CLS to eliminate credit risk. However, it reimports only a small fraction of it. Typically, the value of in-out swaps on any day is equal to about 5 to 7 percent of the gross amount settled, but reduces funding needs to about 2.5 percent of the gross amount that is settled for a particular member (Credit Suisse 2004). There is an upper limit to the volume and value of the in-out swaps depending on bilateral limits between members and overall caps concerning the value of a single in-out swap a member is willing to do on a particular day.

Example of an In-Out Swap

Between 00:00 and 06:30 CET, a settlement member A may enter intra-day swap transactions with settlement member B (FED 2000).

Initial positions

According to the pay-in schedule member A must pay in 2'000 USD at time t and receives a pay out of 3'000 CHF at some later point in time. To cover the pay in of 2'000 USD it is assumed that member A must raise an intra-day credit. Member B's pay-in schedule includes a pay in of 3'300 CHF at time t and a pay out of 1'500 USD at some time later. It is assumed that member B needs to take on an intra-day credit to meet its CHF obligation. The current exchange rate is assumed to be 1.20 CHF/USD. The CLS positions therefore look as follows:

	Member A		Member B	
	USD	CHF	USD	CHF
CLS	-2'000	3'000	1.500	-3'300

Transactions

Member A buys 1'000 USD from member B and sells 1'200 CHF to member B via CLS system. Furthermore member A buys 1'200 CHF from B and sells 1'000 USD to B. This second transaction is settled outside CLS via the national settlement systems SIC and CHIPS respectively. Summarized the positions look as follows:

	Member A		Member B	
	USD	CHF	USD	CHF
Initial positions	-2'000	3'000	1'500	-3'300
Inside CLS transaction	1'000	-1'200	-1'000	1'200
Total in CLS after in-out swap	-1'000	1'800	500	-2'100
Outside CLS transaction	-1'000	1'200	1'000	-1'200
Overall total	-2'000	3'000	1'500	-3'300

While the overall position of the transactions stays the same, the CLS volume can significantly be reduced. Member A's time-critical pay-in obligation is reduced by half (from USD 2'000 to USD 1'000) and member B's by more than one third (from CHF 3'300 to CHF 2'100). Part of the transaction is transferred to the local settlement systems and thus excluded from the tight pay-in schedule of the CLS system. The transfer, however, reintroduces a certain amount of credit risk.

Current Limitations of In-Out Swaps

Even though in-out swaps are an essential part of the CLS system, not every settlement member makes use of them. The main reasons for not participating in in-out swaps are (Credit Suisse 2004): (1) Trading volumes of a specific member are not worth the effort. (2) As the process for the in-out swaps takes place in the early morning hours of CET, for some countries it is difficult to mobilize the necessary work force due to time lags. Not all of the 57 settlement members participate in in-out swaps which somewhat limits the effectiveness of the mechanism as imbalances between in-out swap users and non-users may arise (Credit Suisse 2004). As in-out swaps are matched only on a bilateral basis, the swap will not be executed when the value hits the bilateral limit of these two counterparties. In this case "multilateral" in-out swaps could improve liquidity for the system as a whole (Credit Suisse 2004). A third party with enough liquidity on its CLS sub-accounts would have to be involved to match the in-out swap between the original two parties. For instance, if a member A shows a short position in EUR and is long in USD and another member B has the opposite positions, an in-out swap is still not executed if member A and member B have reached their bilateral limit for in-out swaps. In a world with "multilateral" in-out swaps a third member C currently holding positions within the short position limit could do in-out swaps with both, member A and member B. Even if it might not make sense for this third member to be involved in this transaction it could still improve liquidity for the system as a whole and would not change the net pay-ins of member C.

Top-Up and Contingency Swaps

Besides the in-out swap tool an optional contingency process was established. Some members did not feel comfortable with only the in-out swap mechanism on hand and hence, formed the TUCS Group (Top-Up and Contingency Swap). The TUCS Group is operated manually, mainly via phone calls, it consists of 9 members and is privately organized. Due to the manual nature of the process it seems not very efficient. According to the statement of a member, an appropriate counterparty to enter a swap is only found in about 50 percent of all cases (Credit Suisse 2004).

The Semaphore Group

For the same reasons as the TUCS Group the Semaphore Group was formed. The Semaphore Group includes 18 members. Its operation is similar to the

TUCS Group besides being based on a Reuters whiteboard to announce the funding needs for better matching.

5.6.2 Needs for Other Tools

The need for intra-day liquidity is closely linked to the development of clearing and settlement systems like CLS Bank. Without CLS Bank, for instance, treasury funding is less complex as flows from all kinds of different products are interchangeable. It is only the value date of the trades that needs to be managed by the funding desk. With the CLS system, large volumes of trades are moved to a separate basket, the CLS account. The original funding basket is thus split in two discrete baskets that both need separate liquidity management (Credit Suisse 2004). While the market for overnight funds has evolved in response to these new treasury needs, intra-day markets still need improvement. CLS Bank with its multi-currency settlement and its strict timed payment framework challenges the intra-day markets of multiple currencies. Sophisticated operational infrastructure is required to track and charge for timed intra-day borrowing (CLS 2002*i*).

5.7 Chapter Summary

CLS Bank provides a continuous linked settlement service that simultaneously settles both payments relating to a foreign exchange transaction. It thereby eliminates the risk that one payment could be made and the corresponding counter-payment not received (Herstatt risk). Banks may join CLS as either a settlement member or a user member. Each settlement member holds a multi-currency account with CLS Bank, while user members do not have an account and must instead be sponsored by at least one settlement member. Third party users are not members of CLS Bank and can only settle in CLS Bank through a private arrangement with either a settlement or a user member. Instructions are settled during a five-hour window when CLS Bank debits and credits the relevant settlement member's accounts. While these debits and credits occur throughout the settlement process, settlement members fund pay-ins on a net basis hourly between 07:00 and 09:00 CET. From 09:00 to 12:00 CET the pay-ins and pay-outs are finalized. By 12:00 CET all funds are disbursed back to the settlement members. The hourly pay-in schedule for the CLS funding imposes new challenges to the intra-day liquidity management of a settlement member. The difficulties arising from these changes were identified prior to the start of the CLS system and led to the creation of the in-out swaps. By shifting particular transactions outside

CLS Bank, time and liquidity pressure can be reduced. Liquidity management, however, is still an issue as in-out swaps were planned to be only an interim solution.

Chapter 6

Impact on Credit Risk

Based on publicly available data the following chapter presents two approaches to estimate the effects of CLS on foreign exchange credit risk elimination during settlement. In this chapter, the term credit risk refers to the definition in chapter 3. For simplification, this chapter uses also the term settlement risk as a synonym for credit risk.

6.1 Introduction

One of the most often discussed issues in foreign exchange trading is credit risk arising during settlement (see chapter 3). In 1996 the CPSS (1996) for the first time explicitly addressed the fact that credit risk exposures in foreign exchange settlement are enormous. The report calls on banks, industry groups as well as on central banks to improve the current settlement practices to reduce the credit risk exposures. This public demand note from the Bank for International Settlements set a cornerstone for the foundation of CLS. As described earlier, the settlement process of CLS is set up as a PvP mechanism with credit risk elimination being its main objective. The following sections propose an estimation of CLS's achievement of credit risk reduction during the past years.

6.2 Data Availability

The CPSS (1996) conducted a survey including about 80 banks to estimate the current credit risk at that time. The report concludes that a banks's foreign exchange settlement exposure directly depends on the duration of exposure of each single trade. If the average duration of exposure is two business days, this would result in a permanent credit risk exposure of the average sum of two day's foreign exchange trades. It is estimated that for a large number of banks, this exposure exceeds by far their usual short-term credit lines. To calculate the total credit risk exposure in the industry, the sum of individual exposures would provide an indication. Unfortunately, no figures have been published, neither regarding the value of the trades nor regarding the exposures that were reported by the banks in the survey. The only figures available regarding global foreign exchange markets are the ones reported in the Triennial Central Bank Survey conducted by the BIS (2005 and 2007) and the FX Poll published by Euromoney (2007). In contrast to the Triennial Central Bank Survey which is based on the estimations of 54 central banks (latest version), the current publication of the FX Poll by Euromoney includes more than 8'300 foreign exchange service providers. Both reports release some estimations regarding the global foreign exchange market.

6.2.1 Global Foreign Exchange Turnover

The latest two Triennial Central Bank Surveys were conducted for the month of April in the years 2004 and 2007. According to the survey, the average daily turnover in April 2004 was USD 1'880 billion and USD 3'210 billion in April 2007. Counting both legs of the transactions, results in an average daily turnover of USD 3'760 billion and USD 6'420 billion respectively. Figure 6.1 shows the development of the global foreign exchange turnover since 1992. For the year 2001 and 2004 it shows the currency split for the five most often traded currencies. The underlying numbers were already introduced in chapter 3 (table 3.1, 3.2, and 3.3). As mentioned before, the US dollar is the world's most important currency. In 2007 it had a global market share of approximately 43 percent in the foreign exchange market which means that in 86 percent of all transactions the US dollar was on one side. The US dollar is followed by Euro, Yen, Pound Sterling, and Swiss Francs. The currency split did not change significantly over the past years. After a downturn during the millennium year, total turnover increased by more than 50 percent from 2001 to 2004 and even by 65 percent from 2004 to 2007 (BIS 2007). The second publication regarding foreign exchange turnover is Euromoney's FX poll. The foreign exchange poll 2004 (Euromoney 2004) reports an annual turnover of USD 24 trillion. If this number is divided by 260 working days, an average daily turnover of USD 92 billion results. Counting both legs, the number sums up to USD 184 billion average daily turnover. This is only a fraction of what is reported in the Triennial Central Bank Survey for the same year. Although the report comprises more than 3'500 valid respondents, it does not cover the entire market. The latest poll

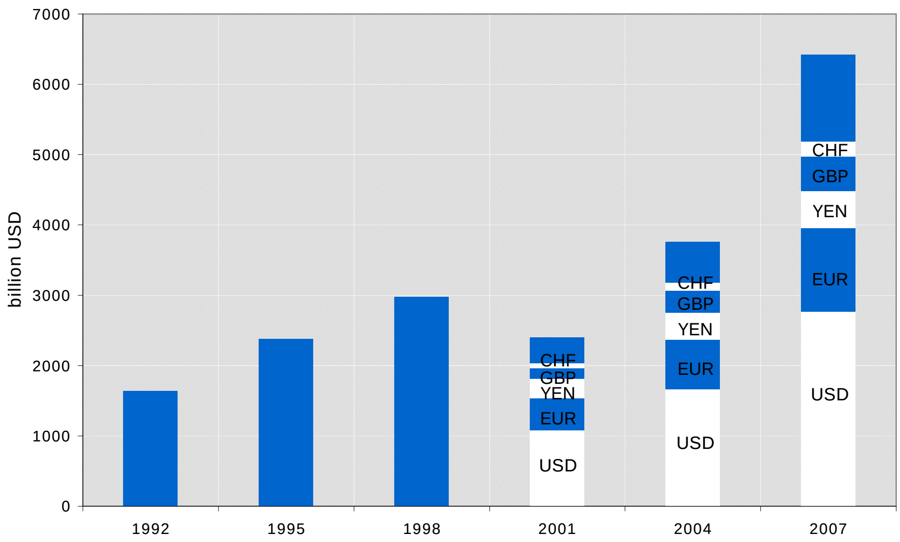

Figure 6.1: Average Daily Foreign Exchange Turnover (BIS 2007).

(Euromoney 2007) encompasses more than 8'300 respondents and reports an annual foreign exchange turnover of about USD 125 trillion which results in an average daily turnover of USD 960 billion (counting both legs). This figure is still far below the numbers reported by the Triennial Central Bank Survey. Euromoney's poll at least provides an idea on who are the largest players in the market. With regard to the global foreign exchange market volume the Triennial Central Bank Survey provides the most cited figures.

6.2.2 CLS Turnover

CLS settlement volume gradually increased since the start of operations in September 2002. Table 6.1 compares the annual number of transactions as well as the annual settlement values of 9 different Large Value Transfer Systems and CLS. The systems that are presented in table 6.1 were selected based on data availability. There are two main reasons for which the CLS figures cannot directly be compared to the figures of the other systems: (1) in contrast to the Large Value Transfer Systems, CLS is not a payment system but a settlement organization. (2) The fact that the actual fund transfer is completed by the respective Large Value Transfer Systems and not by CLS causes the settlement value of CLS to be double counted. In other words, the transaction values that are settled in CLS must be transferred by any of the Large Value Transfer Systems and therefore also appear in their transaction values. Nevertheless, table 6.1 provides an impression regarding scale and growth of CLS. CLS's three-year average growth in both, the number and value of transactions is significantly higher than for the payment systems. Comparing the total transaction value of the payment systems to the value of transactions settled by CLS results in a share of approximately 35 percent in 2005. 35 percent of the payment systems' transfers are therefore assumed to be CLS related. This assumption, however, does not allow for conclusions regarding CLS' share in the foreign exchange market. Payment systems do not exclusively transfer CLS related values but manage a whole range of different payment types. To estimate CLS's share in the foreign exchange market, its settlement value would have to be compared to the portion of foreign exchange related transfers in the payment systems. According to their own statements, CLS's current global market share is estimated to be about 60 to 70 percent. CLS members are assumed to settle even 95 percent of their business with each other via CLS.

	2003	**2004**	**2005**	**3yG**
Number of transactions (in million)				
LVTS (Canada)	4.1	4.4	4.6	5.9%
CHATS (Hong Kong)	4.5	5.1	5.6	11.6%
BOJ-NET (Japan)	4.9	5.2	5.3	4.0%
MEPS (Singapore)	2.1	2.2	2.5	9.1%
RIX (Sweden)	1.4	1.4	1.6	6.9%
SIC (Switzerland)	192.7	209.1	256.4	15.4%
CHAPS (UK)	31.4	33.0	34.7	5.1%
Fedwire (USA)	123.3	125.1	132.4	3.6%
TARGET (EU)	66.8	69.4	76.3	6.9%
CLS	**19.3**	**32.6**	**47.9**	**57.5%**
Value of transactions (in billion USD)				
LVTS (Canada)	22'500	25'400	30'300	16.0%
CHATS (Hong Kong)	12'400	14'500	16'500	15.4%
BOJ-NET (Japan)	161'900	188'800	196'500	10.2%
MEPS (Singapore)	5'700	5'800	7'600	15.5%
RIX (Sweden)	16'100	16'800	17'600	4.6%
SIC (Switzerland)	33'200	33'800	33'000	-0.3%
CHAPS (UK)	117'300	134'700	140'000	9.2%
Fedwire (USA)	447'300	478'900	518'500	7.7%
TARGET (EU)	478'500	558'100	613'600	13.2%
Total	**1'294'900**	**1'456'800**	**1'573'600**	**10.2%**
CLS	**220'600**	**379'500**	**545'800**	**57.3%**
CLS share	**17.0%**	**26.1%**	**34.7%**	

3yG = 3-year average growth rate. For payment systems with multiple currencies, the transaction number and values were added.

Table 6.1: Annual Comparative Turnover (CPSS 2007).

	2004	**2005**	**2006**	**2007**
Annual values (in billion USD)				
Global turnover	977’600	1’167’400	1’396’200	1’669’200
CLS turnover	*379’500	*545’800	*650’000	780’000
Daily values (in billion USD)				
Global turnover	*3’760	4’490	5’370	*6’420
CLS turnover	1’460	2’099	2’500	3’000
CLS share	**39%**	**47%**	**47%**	**47%**

* figures published by BIS or CLS. Calculation assumptions: one year = 260 days, global turnover growth is constant from 2004 to 2007, CLS turnover estimates are based on BIS figures and on a 20 percent growth assumption.

Table 6.2: Credit Risk Elimination Estimates.

6.3 Elimination of Credit Risk

6.3.1 Global Turnover Approach

Under the assumption that the average settlement period during which the face value of the contracts is at risk, is one working day, then the total amount at risk can be estimated as the average daily turnover. For April 2004 this results in an aggregated settlement exposure of USD 3’760 billion. If it is further assumed that all transactions settled via CLS do not include any credit risk, CLS turnover could be subtracted from global turnover. As stated in the previous section, the annual CLS turnover for 2004 was reported as 379’500 billion USD (counting both legs). Dividing this figure by 260 working days results in an estimated daily CLS turnover of 1’460 billion USD. Risky average turnover per day would then equal 2’300 billion USD (3’760 billion USD - 1’460 billion USD). It might be concluded that in 2004, CLS was able to eliminate roughly 40 percent of total settlement risk in the foreign exchange market. Table 6.2 repeats this calculation for the year 2005, 2006 and 2007 by assuming an average growth rate of 20 percent for the global foreign exchange turnover. 20 percent is estimated based on the average growth rate between 2004 and 2007 (BIS 2007). CLS turnover for 2006 is estimated based on the turnover in April 2006 which was provided by CLS. And to estimate CLS turnover for 2007, a 20 percent growth rate is assumed. Under these assumptions, CLS can be estimated to eliminate at about 50 percent of credit risk in the foreign exchange market. It is clear that this estimation is by far too simple. It does not account for any bilateral or multilateral netting arrangements outside CLS that reduce credit risk in the foreign exchange market. There are no estimations for failure probabilities. It is likely that failure probabilities vary among institutions which is reflected in different bilateral limits they set each other. However, even if an average failure probability for the industry as a whole could be estimated, it can be expected that the average failure probability of the remaining trades would change significantly when all CLS trades are excluded. This is because CLS members can be assumed to be rather large and strong industry players. Additionally, the expectations of large increases in global foreign exchange turnover as well as in CLS turnover weakens the significance of the figures. As CLS volumes are growing faster than the global foreign exchange market, it can at least be expected that global settlement risk exposures are decreasing. As mentioned before, CLS today is most likely to eliminate more than 50 percent of settlement risk in foreign exchange markets. These are only the most obvious reasons for the weakness of such an estimation. The main reason for the lack of better information is the absence of comprehensive data availability. An alternative way to estimate the elimination of credit risk due to the introduction of CLS would be to look at an individual bank level.

6.3.2 Individual Bank Approach

Instead of estimating settlement risk on a global level, settlement exposures for individual banks are estimated. Unfortunately, banks in general do not explicitly report on their settlement risk exposures. An exception is UBS. In the UBS (2007) annual report, the bank states that it was able to increase trade volumes without increasing settlement risks to the same extent. The main reason for a reduction in settlement risk is the elimination of credit risk due to an increase in CLS volume. UBS settles about 60 percent of its total foreign exchange volume via CLS and reports a total settlement exposure of 22 percent of gross trade volume. Assuming that the 60 percent CLS volume is settlement risk free, another 18 percent must obviously be eliminated by other means such as netting arrangements. According to the latest FX Poll by Euromoney (2007) UBS is one of the most important players in the global foreign exchange market. It might therefore be a viable assumption that other CLS settlement members playing in the same league regarding foreign exchange trade volume, show a similar risk exposure profile. In the Euromoney (2007) report, the 20 largest market participants (all CLS settlement members) account for more than 90 percent of total turnover. This leads to the assumption, that the volume of all CLS settlement members together represents a substantial part of the global foreign exchange turnover.

It might then be estimated that the global settlement risk elimination by CLS is close to 60 percent. It is obvious that this estimation suffers from similar weaknesses as the global turnover approach. Publicly available data regarding individual bank's exposures is rare and imprecise. The individual bank approach, however, benefits from more current information as it is based on UBS's latest annual report. A more qualitative approach is introduced by TowerGroup that conducted a CLS member survey (TowerGroup 2004). They had 41 responses from settlement members and 137 from third parties. To the question whether CLS has reduced settlement risk, about 80 percent of the respondents answered with a clear yes. None of the settlement members responded with no. Third parties classified risk reduction as the most important factor for the decision to participate in CLS. Altogether these different statements denote a significant increase in CLS' market penetration and a substantial reduction of foreign exchange settlement risk. This points to the fact that CLS has well achieved its main objective. It satisfied the request called on the industry by the Bank for International Settlements in 1996 and helped the market to grow further.

6.4 Chapter Summary

The main objective of CLS is to eliminate credit risk. This chapter offers some insights to the achievements of CLS in this regard. Although estimations of global credit risk exposures are rather vague, an analysis at an individual bank level provides some indications. The figures suggest credit risk eliminations of roughly 40 percent of total foreign exchange turnover in 2004 to about 60 percent today. The main problem of the estimations presented in this chapter is the lack of data availability. Even though the evidence from publicly available figures cannot be considered strong, there is some indication that CLS has well achieved its objective to reduce settlement risk in a globally growing market.

Chapter 7

CLS Settlement Structure

The previous chapter provided estimations regarding the achievement of credit risk elimination in the global foreign exchange market. It leads to the conclusion that risks could be lowered substantially since the introduction of CLS. As CLS members were able to increase their trading volume and value by more than the corresponding settlement risk, CLS can be assumed to be a driver for market growth. The number of CLS participants, in particular the number of third parties, has grown significantly and might have affected trade relationships among each other. This chapter presents an empirical study regarding the changes in trade relationships among CLS participants. Based on a network model and a unique data set provided by CLS, the structure of trade partners settling their foreign exchange deals in CLS is analyzed over time. The chapter starts off with an overview on network literature and a description of the relevant network statistics before introducing the data set.

7.1 Network Literature Review

Network theory is based on concepts of discrete mathematics known as graph theory. The classical model of network is called random graph. It basically consists of a fixed number of nodes and a randomly distributed number of links between these nodes. This kind of network was first described by Rapoport & Solomonoff (1951) in the early 1950s. Ten years later, Erdös & Rényi (1960) published a series of papers discussing the random graph in depth. Their work is considered the most influential to current network science (Newman, Barabási & Watts 2006). During the same years, based on random graph theory, the sociological community started to develop a new class of random graph networks, the so called small-world networks. The typical characteristic of this class of networks is that every node can be reached from every other node in only a few steps. Pool & Kochen (1978)[1] analyzed patterns of social contacts and with it, set the base for many other articles in the area of social networks (e.g. empirical studies by Milgram (1967) and Travers & Milgram (1969)). Also information science soon started to make use of small-world network models. Price (1965) was the first to study the network of citations between scientific papers. Today, not only social and citation networks but also the connectivity of the internet or gene networks can well be described by small-world networks (Watts & Strogatz 1998). More recently, enhanced data availability enabled empirical studies of complex real networks such as the World Wide Web or biochemical networks. Simple network structures such as the random graph turned out not to be powerful enough to understand and quantify the structure of these complex networks found in the real world. One of the most famous works was conducted by Albert, Jeong & Barabási (1999) who described the degree distribution of the World Wide Web approximately as a power law distribution. Barabási & Albert (1999) introduced the term of scale-free networks and set a new direction for network research (Newman et al. 2006). A large number of papers by various authors dealing with scale-free networks has been published ever since. In the wake of the extensive scale-free network research during the past years, the banking and finance community started to make use of these models. Payment- and settlement systems, shareholder ownership, as well as borrowing and lending relationships can well be described and analyzed based on the topology of scale-free networks. Their topological properties allow for conclusions regarding resilience and contagion in case of systemic failure or attacks. Important work in that context has been conducted by Albert & Barabási (2000) who found that scale-free networks display a high degree of robustness but are extremely vulnerable to systematic attacks. Their and other findings regarding network topology were adapted to several different aspects of corporate dynamics and the banking system. A selection of different publications is summarized in the following. Based on a data set of the Österreichische Nationalbank, Boss, Elsinger, Summer & Thurner (2003) conduct an empirical study of the network structure of the Austrian interbank market. They show that the distribution of mutual credit relations can be modelled as a scale-free network. A social network approach was used by Battiston, Bonabeau & Weisbuch (2003) to predict the decision dynamics outcome in corporate boards. Iori, Masi, Precup, Gabbi & Caldarelli (2005) use network statistics to analyze the Italian overnight money market. They look at the lending and borrowing activities of banks with different sizes. It

[1]The article was written in 1958 but not published until later.

allows them to draw conclusions regarding the optimization of institutional settings to minimize the risk of contagion and systemic failure in the banking system. Rossi & Taylor (2005) model the Brazilian inter-city banking relations as an interlocking network. It allows them to construct cartograms to show the relative importance of different Brazilian cities regarding domestic and international banking activity. Garlaschelli, Battiston, Castri, Servedio & Caldarelli (2005) propose a network description of large market investments. In their model, stocks and shareholders are represented by nodes while the links between these nodes are defined as the corresponding stock ownerships. They find that the distribution of assets held and the invested wealth follow a power law. A publication by Inaoka, Ninomiya, Taniguchi, Shimizu & Takayasu (2004) analyzes the network structure of financial transactions, using the logged data of transactions via BOJ-Net. They show that interactions between financial institutions display fractal structure[2]. The work done by Soramäki, Bech, Arnold, Glass & Beyeler (2006) is based on a similar idea. They explore the network topology of interbank payments transferred via Fedwire. A set of network statistics is applied to determine weather the properties of the payment network has changed since the attacks of September 11, 2001. Lublóy (2006) describes the topology of the Hungarian large value transfer system and finds a permanency over time. This is not a complete list of work conducted in this area but provides an impression of the current empirical research in the area of scale-free network statistics applied to financial economics.

7.2 Network Analysis

Mathematics and physics have proposed a broad set of topological statistics to characterize complex networks (Albert & Barabási (2002), Newman (2003), Newman (2004) and Barthélemy, Barrat, Pastor-Satorras & Vespignani (2005)) which have been adapted by the economic community (Iori et al. (2005) and Soramäki et al. (2006)). The following section presents a set of definitions that are used to analyze the subsequent network model. A network is a set of items, that are called nodes, with connections between them, called links. In most mathematical literature the term graph is used instead of network. Binary networks have links that are either present or not. This kind of network can be represented by $(0, 1)$ or a binary matrix. The matrix, called the adjacency matrix A is defined as an $N \times N$ matrix where N is the

[2]Fractal is a shape that is recursively constructed and hence appears similar at all scales of magnification. For mathematical definition see "Benoît Mandelbrot, 1982: the Fractal Geometry of Nature".

number of nodes in the network. If there is a link from a node n_i to a node n_j, then the element a_{ij} of the matrix A is 1, otherwise it is zero:

$$a_{ij} = \begin{cases} 1 & \text{if } n_i \text{ and } n_j \text{ are connected,} \\ 0 & \text{otherwise.} \end{cases} \tag{7.1}$$

In this case the links a_{ij} are unweighted. They are simply either existent or non-existent. In a weighted network, links have weights attached to themselves. Mathematically, such a network can be represented by an adjacency matrix with entries that are equal to the weights on the links:

$$w_{ij} = \text{weight of connection from } n_i \text{ to } n_j \tag{7.2}$$

The most basic characteristic of a network is its **size** N, defined as the number of nodes in the network. Each node has its own **degree** k_i defined as:

$$k_i = \sum_{j \in \mathcal{V}(i)} a_{ij} \tag{7.3}$$

$j \in \mathcal{V}(i)$ represents the set of all neighbor nodes of i. Hence, the degree of a node i is the number of links connected to this particular node i. Links can either be directed or undirected. In a network with directed links, nodes have both, an in-degree and an out-degree. They represent the numbers of incoming and outgoing links respectively. Along with the degree of a node, an important measure of the network properties in terms of the actual weights is obtained by looking at the strength of the nodes. The **strength** s_i of a node is the result of the sum of all weighted links connected to that node:

$$s_i = \sum_{j \in \mathcal{V}(i)} w_{ij} \tag{7.4}$$

The **connectivity** c_i of a node is given by the number of links relative to the number of possible links in the network. It is hence the unconditional probability that two nodes are connected by a link:

$$c_i = \frac{k_i}{(n-1)} \tag{7.5}$$

The probability distribution that a node has exactly degree k is the so called **degree distribution** $p(k)$. It is a function describing the total number of nodes with a given degree. Equivalently, $p(k)$ is the probability that a node chosen at random has degree k. The degree distribution of a network can be plotted by drawing a histogram of the degrees of all nodes in the network. The degree distribution of most networks observed in the real world are found to be highly right skewed. This means that there are a few nodes with a degree number far above average. Formally, the degree data is best presented by a plot of the cumulative distribution function $P(k)$ which is the probability that the degree of a node is greater than or equal to k:

$$P(k) = \sum_{k'=k}^{\infty} p(k') \tag{7.6}$$

The distribution that is most common to real world networks follows a power law. Networks featuring power law degree distributions are often referred to as scale-free networks[3]. Most of their nodes are of low degree but a minority exhibits a high degree and can be interpreted as highly connected hubs.

7.3 The Data Set

The data set for this analysis was provided by CLS Bank. It includes trade values transmitted to CLS for settlement in dollar equivalents of 54 settlement members and 391 third party users aggregated on a daily basis for the month of April in 2006. It is important to understand that the data is reported on a bilateral gross basis. This means that there are three different types of records: the daily gross settlement value between (1) two settlement members, (2) a settlement member and a third party, and (3) two third parties. It does not provide information regarding the settlement arrangements between settlement members and third parties. In other words, a settlement relation between a settlement member and a third party (record type 2) does not necessarily indicate that this particular settlement member is the third party's settlement bank. It only indicates that this particular settlement member has a trade relationship with that third party. The same is true for record type 3. On an operational level, both third parties must settle via their settlement bank as they do not have direct access to CLS. This operational level is not reflected in the data set. It only reflects settlement relations stemming from trade relations. To analyze the development of this trade relationship structure over time, the April 2006 data is compared to the transaction data of April 2005, 2004, and 2003. The month of April as point of reference was chosen to be consistent with the surveys of the Bank for International Settlements. Yet, the figures reported by the Bank for International Settlements cannot directly be compared to the figures presented here.

[3] The term scale-free refers to any functional form $f(x)$ that remains unchanged when the independent variable x is rescaled. Since the only solutions to $f(ax) = bf(x)$ are power law forms, the term power law and scale-free are synonymous in this context.

The latter represent settlement values while the former represents trade values. The trades underlying the settlement values may have been completed several days or even months ago. To apply network statistics to these settlement transactions, the following is defined. The participants of CLS form the nodes of the network. The nodes are categorized by sm-, and tp-nodes. Settlement members are represented by sm-nodes, and third party users are reflected by tp-nodes. A link between any two nodes exists if the corresponding CLS participants have settled at least one foreign exchange transaction via CLS. For a particular settlement transaction, both nodes involved can be seen as a sender and receiver node, because each settlement transaction has two legs. Neglecting currency rate fluctuations, the value of these two legs is equal. Each settlement transaction, therefore, consists of a pair of directed links with equal value. For simplification, the following analysis only looks at undirected links, or in other words, only at one side of the transaction. To do so, each node is interpreted as a sender node.

7.4 Research Design

To keep the analysis straight forward and to avoid over interpretation, a set of basic suppositions is defined. Due to the fact that the data is encoded, it does not allow for a detailed analysis regarding specific CLS participants. As a consequence, the following suppositions are intentionally kept at an elementary level.

1. The largest part of settlement value is generated by settlement members.
2. Large settlement members grow even larger in terms of settlement value and number of trade partners.
3. Settlement members with large overall settlement values deal with a larger number of third parties.
4. Settlement members with many trade relations in total, deal with a larger number of third parties.
5. Settlement members with a large number of third parties tend to attract more third parties as trade partners.
6. New third parties tend to be smaller than already existing ones.

After having presented the data's statistics, the subsequent sections elaborate on these suppositions. Section 7.7.1 is dedicated to supposition 1 and 2,

	2003	2004	2005	2006
Settlement Members				
Quantity	53	54	57	54
Total gross value	15'400	25'500	36'800	43'000
Mean	290	470	620	800
Median	120	250	340	480
Max	1'680	2'210	3'110	3'770
Min	0	0	0	0
Stdv	380	540	730	900
Third Parties				
Quantity	36	118	257	391
Total gross value	600	2'700	5'000	8'200
Mean	17	23	19	20
Median	0.9	3	0.9	0.2
Max	180	720	880	1'040
Min	0	0	0	0
Stdv	40	80	70	80

Except for "Quantity", all values in billion USD.

Table 7.1: Descriptive Statistics.

section 7.7.2 treats supposition 3, 4, and 5. While these suppositions are from the settlement members' point of view, section 7.7.3 changes side and takes the view of the third parties.

7.5 Descriptive Statistics

Table 7.1 provides the descriptive statistics of the data set. The number of settlement members varies between 53 in 2003 and 57 in 2005. Besides a few new settlement members, merger and acquisition activities are the main reason for the number of settlement members to vary. The gross value (GV) that was settled by settlement members in the month of April 2006 was about 43 trillion USD. Gross value was increasing year by year. The so called ramp-up pricing (see p.65) assured that settlement members would push CLS transactions during the first years of CLS's operations. This is reflected in high value growth rates in 2003 and 2004. From April 2003 to April 2004 gross value increased by more than 60 percent. Even though the gross value growth rate is declining, it was still around 17 percent from 2005 to 2006. In April 2006 each settlement member completed transactions worth around 800 billion USD on average. As indicated by mean and median, gross value seems not to be equally distributed among the settlement members. The median being lower than the mean suggests a right skewed distribution of gross value. As displayed in figure 7.1, 75 percent of the settlement members settled gross values less than one trillion USD each. This accounts for only one third of total value settled. At the other tail of the distribution two settlement members settled more than 3 trillion USD. The three largest settlement members generated 25 percent of total gross value in April 2006. The characteristics of this gross value distribution are similar in each year. Average and median gross value have grown roughly in line with total gross value. The number of third parties considerably increased from 36 in April 2003 to 391 in April 2006. Total gross settlement value increased sharply from April 2003 to April 2004 and grew in line with the number of third parties thereafter. In April 2006 around 8 trillion USD were settled by third parties. Mean and median, being far apart from each other, stay around the same levels over the sample years. As figure 7.2 shows, the skewness of the gross value distribution of third parties is much stronger than the one for settlement members. In April 2006, 75 percent of the third parties accounted for only 3 percent of total gross value. The largest 10 percent of the third parties account for more than 80 percent of value. Or to put it differently, almost 90 percent of all third parties generate settlement values less than 55 billion USD. The largest third party accounts for almost twice as much of total value as the second largest third party in the sample. These figures suggest strong power law characteristics. This means that the majority of third parties generates low volumes while a relatively small group of third parties generates a major portion of total value. This is true for all years included in the sample. It seems that among settlement members as well as among third parties, the value distribution characteristics have not changed much over time. The distributions are right skewed in all years and do not indicate any shifts in the value structure within the group of settlement members or third parties. In each year, relatively small groups of settlement members and third parties generated significant portions of the respective settlement value.

7.6 Network Statistics

This section presents the data set in terms of the network statistics introduced in section 7.2 and offers a visualization of the network. In April 2006, the network consists of 54 sm-nodes and 391 tp-nodes which results in an overall

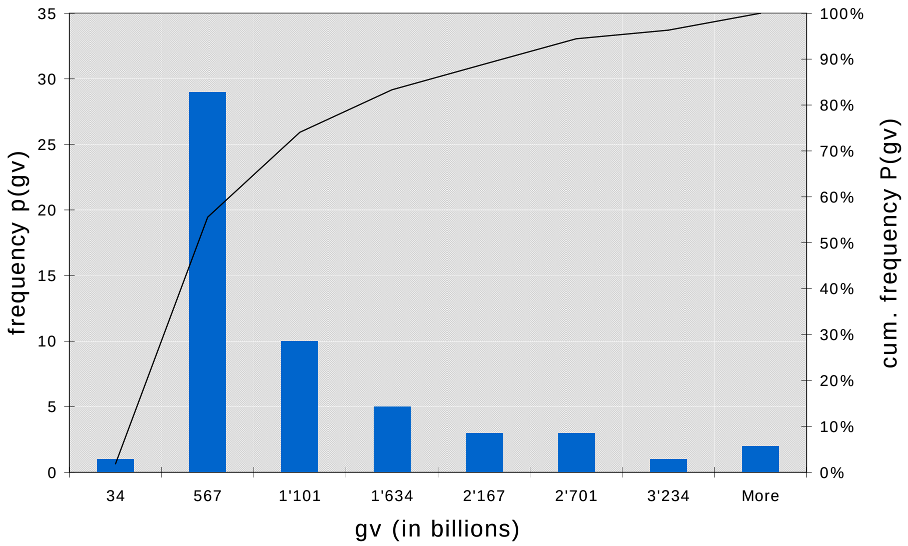

Figure 7.1: GV Distribution of Settlement Members in April 2006.

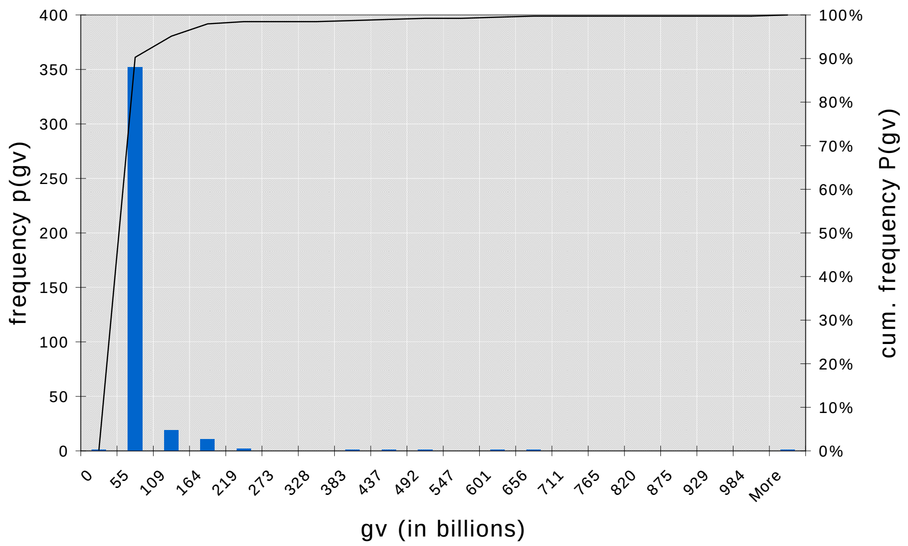

Figure 7.2: GV Distribution of Third Parties in April 2006.

	2003	2004	2005	2006
Size	89	172	314	445
Degree				
Mean	40	49	41	37
Median	49	45	18	10
Min	1	1	1	1
Max	72	128	196	285
Stdv	25	39	48	53
Strength (in billion USD)				
Mean	180	164	131	115
Median	48	13	3	1
Min	32	0	0	0
Max	1'680	2'210	3'110	3'770
Stdv	323	370	397	409
Connectivity				
Mean	45%	29%	13%	8%
Median	56%	26%	6%	2%
Min	1%	1%	0%	0%
Max	82%	75%	63%	64%
Stdv	28%	23%	15%	12%

Table 7.2: Network Statistics.

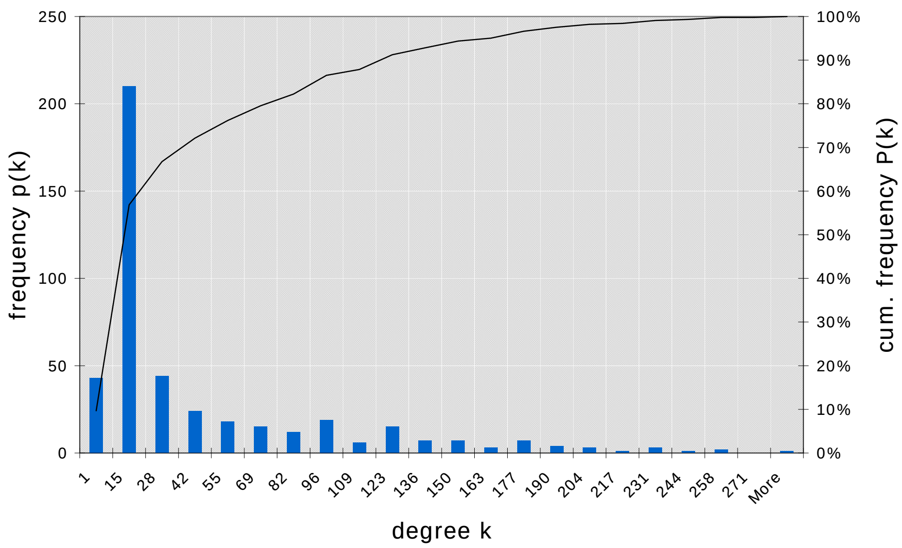

Figure 7.3: Degree Distribution in April 2006.

network size of 445 nodes. Table 7.2 shows the relevant network statistics from 2003 to 2006. The descriptive statistics in table 7.1 already showed the increase in the network's size. From 89 nodes in 2003 the network grew to 445 nodes in 2006. The degree of a node represents the number of trade partners that a particular settlement member or third party had a relation with in April of the respective year. The minimum degree, consequently, must be at least one. It seems that after 2004, mean and median degree start to drift apart. While the average number of trade partners seems to stay relatively constant, the median degree decreases. This development might indicated that the new nodes in the network are of relatively low degree. This seems to be a reasonable interpretation considering that the new nodes are predominantly third party nodes of which it can be assumed that they are less active in trading than settlement members. Figure 7.3 shows the degree distribution for April 2006. Half of all the nodes have a degree lower than 10 while about 15 percent of the nodes have a degree that is higher than 100. The degrees cannot be considered as approximately normal distributed. In fact, the distribution shows rather power law characteristics. The strength of a node is the sum of its weighted links. A link represents a trade partner relationship and the corresponding weight equals the gross value that is exchanged via this trade relation. Average node strength, therefore, equals the average gross settlement value per participant. Mean and median being far apart indicate that there is a small group of nodes with high strength while the majority of nodes are of low strength. This characteristic was already observed by means of the descriptive statistics in section 7.5. In figures, this means that about 90 percent of all nodes have a strength that is lower than 350 billion USD. This sums up to a little more than 10 percent of gross settlement value. In contrast, the top ten percent of nodes in terms of strength account for almost 90 percent of gross settlement value. The network is highly heterogeneous in terms of its nodes' strengths. The connectivity of the network was higher in 2003 and decreased gradually each year. In 2006 the network shows a connectivity of 8 percent. This figure can be interpreted as the probability that a node has a link to any other particular node in the network. It is clear that over time, the connectivity shows the same development as the degree distribution. Mean and median are drifting farther apart from year to year, indicating the development of power law characteristics. The graphical representation of the network underlines this impression. Due to the fact that a graph of the entire network rather evokes the notion of a massive cotton wool ball, a minimum transaction value had to be set to reduce the number of links. Figure 7.6 and 7.7 at the end of the chapter, show organic layouts of the network in 2003 and 2006 with a minimum link weight of 5 billion USD. The term organic layout refers to the type of graph layout. It arranges nodes as if they were physical objects repulsing each other. The links between the nodes hold them together. Heavier links are colored darker. The position of a node is determined by the number of links of that node. Nodes with more links are located closer to the center of the network. The resulting graphical configuration of the nodes and links represents an equilibrium of their forces. As mentioned earlier, each node is interpreted as a sender node which results in onesided links between them. If both legs of the transactions would be displayed, the links would be two-sided and their weight would double. The direction of the links, therefore, does not provide any additional information. The graphs clearly show the large growth of the network from 2003 to 2006. Nodes that were central in 2003, are also central in 2006. Peripheral nodes in 2003 seem to have moved towards the center and were replaced by new nodes, including also tp-nodes. Additionally, strong triangular relationships among the central sm-nodes evolved and some of them clearly show hub characteristics. In summary, the graphical representation confirms at first glance what was suggested by statistics. The following section takes a closer look at the two different types of nodes. To do so, the network is split into two subgraphs. The first consists of all sm-nodes, the second includes the set of tp-nodes.

	2003	2004	2005	2006
SM Subgraph Connectivity				
Mean	89%	96%	88%	92%
Median	94%	98%	93%	96%
Min	6%	49%	7%	13%
Max	100%	100%	100%	100%
Stdv	19%	8%	17%	16%
TP-Connectivity				
Mean	27%	36%	26%	24%
Median	31%	36%	28%	23%
Min	0%	1%	2%	3%
Max	61%	64%	55%	59%
Stdv	17%	16%	14%	14%

Table 7.3: SM-Subgraph Statistics.

7.6.1 SM Subgraph

The network size for the sm subgraph varies from 53 to 57 nodes. Table 7.3 shows the connectivity statistics for the subgraph and additionally displays the tp-connectivity which is defined as the connectivity of sm-nodes to tp-nodes. Strictly speaking the latter is not a statistic of the sm subgraph but describes the connectivity of the sm-nodes with regard to the tp-nodes. It is the number of third parties that a particular settlement member deals with in relation to the number of all third parties that it could deal with. A settlement member that has trade relations with each single third party would show a tp-connectivity of 100 percent. Settlement members that do not trade with any third party show a tp-connectivity of zero. The tp connectivity in table 7.3 indicates relatively stable connectivity over time. In 2006, settlement members had around 90 trade relations with third parties in average. The maximum number was 232 third party trade relations for one settlement member, the minimum 10. Figure 7.4 shows the corresponding degree distribution. Unlike most other distributions presented earlier, this one does not show power law characteristics. Third party trade relations rather convey the impression of being normally distributed among the settlement members. Coming back to the first part of table 7.3, it shows a highly connected sm-network. A major part of the settlement members had trade relations with most other settlement members in the network. This is not a surprise, as settlement members can be considered as large market players. Nevertheless, there are a few settlement members that show less than 10 re-

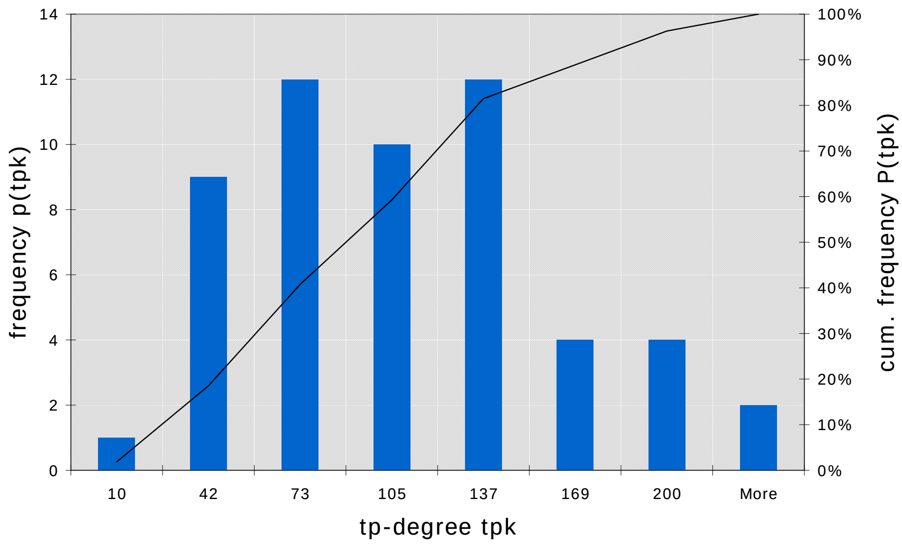

Figure 7.4: TP-Degree Distribution in April 2006.

lations to other settlement members. Neither the subgraph connectivity nor the tp-connectivity points to significant structural changes over time.

7.6.2 TP Subgraph

The subgraph consisting of tp-nodes grows significantly from 36 nodes in 2003 to 391 nodes in 2006. As displayed in table 7.4, the average subgraph connectivity is low compared to the sm-subgraph. In average, a third party has trade relationships with only 9 other third parties. The median, laying below the mean, indicates that it is a small group of third parties that supports numerous trade relations with other third parties. Even though there are several third parties that do not trade with any other third party, the maximum number of trade relations among two third parties was 143 in 2006. The sm-connectivity is defined as the number of trade relations that a third party maintains with settlement members compared to the total number of settlement members. Table 7.4 shows that in each year at least one third party did not have any trade relations with settlement members. At the other end, at least one third party had relations with all settlement members except one. In average, third parties had around 13 trade relations to settlement members in 2006. Figure 7.5 underlines these characteristics. The trade relations to settlement members cannot be considered normally distributed among third parties. The larger part of third parties maintains relatively few

	2003	2004	2005	2006
TP Subgraph Connectivity				
Mean	6%	8%	4%	2%
Median	0%	3%	0%	0%
Min	0%	0%	0%	0%
Max	34%	49%	31%	37%
Stdv	9%	10%	6%	5%
SM-Connectivity				
Mean	27%	36%	26%	24%
Median	19%	31%	9%	13%
Min	0%	0%	0%	0%
Max	81%	94%	95%	98%
Stdv	27%	31%	27%	27%

Table 7.4: TP-Subgraph Statistics.

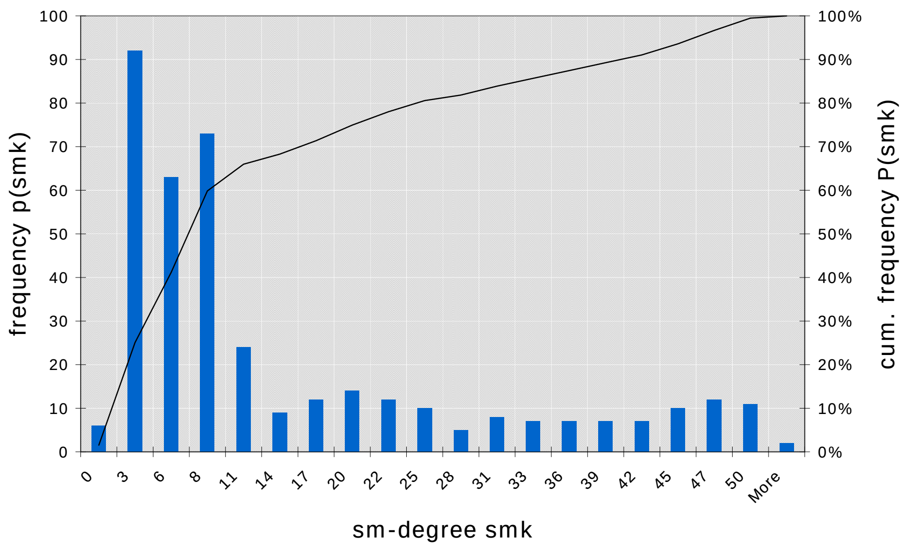

Figure 7.5: SM-Degree Distribution in April 2006.

relations to settlement members while about 10 percent of the third parties has relations to more than 40 different settlement members. Looking at the development over time, again shows mean and median drifting apart since 2005. This observation might be considered consistent with what was stated in section 7.6. It seems reasonable to assume that new third parties with rather low sm-connectivity have entered the network since 2005. In general, the subgraph perspective confirmed substantial differences in the structure of sm-nodes and tp-nodes. While the network of sm-nodes is highly connected and does not seem to undergo significant shifts over time, the network of tp-nodes is of relatively low connection and alters its degree distribution over time. In contrast to the sm-nodes that show relatively normal distributed connections to third parties, the tp-nodes rather show power law characteristics in terms of the number of settlement member trade partners. Figure 7.8 at the end of the chapter, offers a graphical approach to these suggestions. It represents an organic layout with a minimum link weight of 2 billion USD. The visualization makes clear that the tp-subgraph (tp-nodes are marked in red, corresponding links in blue) tend to be located at the periphery of the network while sm-nodes form the core. There are a few tp-nodes that are highly connected and, referring to their location in the network, could just as well be sm-nodes. The following section provides further insights into the structure suggested by the statistics and deals in particular with the assumptions presented in section 7.4.

7.7 Further Results

7.7.1 Development of SM Size

This section deals with supposition 1 and 2 that were introduced in section 7.4 (p. 110). **Supposition 1** in the research design can easily be confirmed by looking at table 7.1 or the graphical representations of the network. The largest part of gross settlement value is generated by settlement members. As figure 7.1 already demonstrated, gross value is not equally distributed among settlement members. The 5 largest settlement members account for more than 50 percent of gross value. The fraction of value that is produced by third parties is proportionately small. It was 6 percent in April 2003, but grew in each of the following years. In April 2004, 2005, and 2006 third party value contingent amounted to 11, 14, and 20 percent respectively. As third party value seems to grow much faster than settlement member value, it might be a reasonable expectation that the portion of third party value will exceed 20 percent of total settlement value in the next years. For the

	GV03	GV06	GVg06	GVg03-06	k06	kg03-06
SM1	1'700 (1)	3'000 (3)	3% (30)	21% (44)	200 (9)	142% (15)
SM2	1'500 (2)	3'800 (1)	21% (19)	36% (34)	254 (2)	155% (5)
SM3	1'100 (3)	2'200 (6)	10% (26)	27% (41)	243 (4)	151% (8)
SM4	1'100 (4)	3'500 (2)	54% (6)	48% (21)	285 (1)	160% (4)
SM5	1'100 (5)	2'600 (4)	25% (13)	34% (36)	227 (5)	154% (6)

Rankings in parentheses. GV03/06 = gross value 2003/2006 in billion USD. GVg06/03-06 = gross value growth from 2005-2006/2003-2006. k06 = degree 2006. kg03-06 = average degree growth from 2003 to 2006.

Table 7.5: Top 5 Settlement Members.

second supposition, the correlation of gross value, gross value growth, degree, and degree growth is analyzed. Table 7.5 summarizes the top 5 settlement members in terms of gross value. Settlement members that were not existent in at least one of the four years were excluded from this part of the analysis. Thereby, the sample was reduced to 50 settlement members. The table is sorted by gross value in April 2003 and additionally shows gross value in April 2006, the corresponding growth rate from 2005 to 2006, the average growth rate from 2003 to 2006, as well as the corresponding degree in April 2006, and the average growth in degree from 2003 to 2006. The figures in parentheses indicate the respective rank. The correlation matrix displayed in table 7.6 serves as the basis to explore whether large settlement members grow even larger in terms of gross settlement value. It relates the gross value in 2003 to the one in 2006 as well as to different growth periods and to the number and growth of the degrees. Looking at table 7.6, reveals that besides the correlation of gross value in 2003 and 2006 and the correlation of the gross value and the degree, none of the coefficients is large enough to be considered as statistically significant. A correlation of 0.88 between gross value in 2003 and gross value in 2006 indicates that settlement members which already had large gross settlement values in April 2003 tend to have large gross settlement values in April 2006. Though not statistically significant, the average value growth from 2003 to 2006 shows negative signs when related to the gross value in 2003 and 2006. As mentioned before, settlement members that were large in 2003, tend also to be large in 2006 but do not explicitly show higher value growth, neither from 2003 to 2006 nor in the year 2006. Average value growth from 2003 to 2006 is not significantly correlated to the value growth in 2006. This suggests that settlement members with high average growth over the four year period are not the same ones

	GV03	GV06	GVg06	GVg03-06	k06
GV06	0.88				
GVg06	-0.03	0.13			
GVg03-06	-0.27	-0.07	0.05		
k06	0.72	0.86	0.00	0.00	
kg03-06	0.01	0.36	0.17	0.31	0.38

GV03/06 = gross value 2003/2006 in billion USD. GVg06/03-06 = gross value growth from 2005-2006/2003-2006. k06 = degree 2006. kg03-06 = average degree growth from 2003 to 2006.

Table 7.6: Correlation Matrix.

that have experienced high growth in 2006. It seems that in each year there are alternating settlement members with high value growth rates. According to table 7.6 there is a positive correlation between the degree in 2006 and the gross value in 2003 (0.72) and even stronger in 2006 (0.86). Settlement members with large settlement values in 2003 and 2006 tend to maintain a large number of degrees in 2006. Looking at the average degree growth over the four year period does not reveal significant correlations with any of the other variables. The coefficients of zero for value growth and number of degree indicate that it is not the settlements members with high value growth that have large degrees. Furthermore, settlement members with high value growth do not necessarily also grow in the number of degrees. In addition, settlement members that show large degrees in 2006 do not seem to have high degree growth rates over the four year period. In summary, table 7.6 suggests that in 2006, settlement members with large gross settlement values tend to have high degrees and that these settlement members already had similar characteristics in 2003. Regarding **supposition 2** in section 7.4 (p. 110) the following conclusions might be drawn: (1) large settlement members still show positive value growth rates and thus grow larger. But it is not the largest settlement members that have the highest value growth rates. (2) Larger settlement members in terms of settlement value always had more trade partners. In contrast, smaller settlement members tend to have higher growth rates for both, gross value and degree. Based on these observations, the development of settlement member size is assumed to stay relatively constant. As the graphical representation of the network already showed, nodes that were central in 2003 kept their position up to 2006 and increased the number of links as well as their weight. The size ranking, therefore, is not likely to change in the short run.

	2003	**2004**	**2005**	**2006**
ρ_1	0.62	0.61	0.67	0.86
ρ_2	0.62	0.55	0.58	0.80
ρ_3	0.88	0.97	0.89	0.99
ρ_4	0.56	057	-0.01	0.10
ρ_5	-0.46	-0.30	-0.18	

$\rho_1 = GVsm \sim tpk$,
$\rho_2 = (GVsm/k) \sim tpk$,
$\rho_3 = k \sim tpk$,
$\rho_4 = tpk \sim (tpGV/GV)$,
$\rho_5 = tpk \sim tpkgrowth/avg.growth.$

Table 7.7: SM Business Structure Correlation.

7.7.2 SM Business Structure

This section treats supposition 3, 4, and 5 that were presented in section 7.4 (p. 110). It provides insights into the third party business structure by looking at the development of the relationships between settlement members and third parties. It must be emphasized once again that the linkage between settlement members and third parties in this context does not reveal any information regarding the operational settlement relation between them. The observed relations merely represent trade relationships and not settlement arrangement. For the same reasons as in the previous section, the sample was reduced to 50 settlement members. Referring to supposition 3, settlement member gross value is compared to the number of third parties that they maintained relations with. As already confirmed for supposition 2, larger settlement members show higher degrees, indicating that they have more overall trade relations than smaller settlement members. So far it was not distinguished between trade relations to other settlement members or to third parties. ρ_1 in table 7.7 shows the correlation coefficient for settlement member gross value and the number of third party relations. The number of third party relations is defined as the third party degree. Except for 2006 the correlation cannot be considered to be significant. Hence, it is yet not clear whether there is dependency between gross value and third party degree. Because the gross value is likely to be dependent on the number of total trade relations, gross value is divided by its corresponding degree to receive a relative gross value. Computing the correlations between these relative gross values and the third party degrees results in ρ_2 that is displayed in table 7.7. It shows the same picture as for absolute gross values. Before 2006, there was no significant correlation between settlement member size and number of third party relations. Consequently, **supposition 3** cannot be confirmed for these years. Only for 2006 it might be stated that larger settlement members in terms of total settlement value deal with a larger number of third parties. Supposition 4 refers to the question whether there is a relation between the total number of trade partners and the number of third party trade partners. The idea is the same as for supposition 3, except that size is redefined as number of trade partners instead of gross value. As ρ_3 in table 7.7 shows, the correlation of total degree and third party degree is very high. This is not a surprise. The total degree is mainly driven by the third party degree due to the fact that the settlement members are highly connected (see table 7.3). For this reason it seems more interesting to suppose that settlement members with a large number of third party trade partners also generate a large fraction of their gross value with those third parties. A positive correlation might indicate that there are settlement members with a third party focus. The average fraction of settlement member gross value that was generated by third party relations increased from 3 percent in 2003 to 16 percent in 2006. ρ_4 shows the correlations between these fractions and the number of third party connections. No significant dependency is detected. The fraction of the settlement members' gross value that they generate with third parties does not depend on the number of third parties they deal with. In 2006 for instance, there are three settlement members that generate more than 40 percent of their total value with relations to third parties. The number of third parties that they deal with, however, varies between 12 and 113. In summary, **supposition 4** can be confirmed, though it might not provide much additional information. The fact that there is no correlation between the number of third party relationships and the business value generated with them seems somewhat surprising. It might indicated that the relations between settlement members and third parties are divers and rather randomly distributed. This will further be explored in the context of supposition 6. Supposition 5 treats the question whether some concentration process in third party relations can be observed. It is analyzed if settlement members with high third party degrees also show large growth in the third party degree relative to total third party degree growth in that year. ρ_5 in table 7.7 does not show any significant correlation between these two factors. Settlement members with many third party relationships do not show larger growth in new third party relationships for the following year. **Supposition 5** can thus not be confirmed. The tp-degree distribution of the sm subgraph that was presented in figure 7.4 supports this picture. It does not show strong skewness in settlement members' third party degrees.

If a concentration would have proceeded during the last years, the distribution would rather show power law characteristics. Summarizing the insights from supposition 1 to 5 leads to the conclusion that today settlement members account for about 80 percent of gross CLS settlement value. Settlement member value is highly concentrated as the 5 largest settlement members account for more than 50 percent of total settlement member value and almost 30 percent of overall gross settlement value. They are highly connected to other settlement members and deal with a larger number of third parties. The fraction of value that they generate with them, however, is not above average. The development during the past years shows a relatively stable size ranking and does not suggest any significant future shifts in the settlement member structure. Coming back to supposition 1 to 5, the responses look as follows:

1. Figures confirm that the largest part of settlement value is generated by settlement members.
2. Large settlement members show positive growth rates in settlement value and number of trade partners. Growth rates of smaller settlement members, though, seem to be higher.
3. Except for 2006 it cannot be confirmed that larger settlement members in terms of value also deal with a larger number of third parties.
4. It seems true that settlement members with many trade partners deal with a larger number of third parties. But somewhat surprisingly, the portion of value that they generate with third parties is not related to that number.
5. It could not be confirmed that settlement members with a large number of third parties tend to attract more third parties as trade partners.

7.7.3 TP Business Structure

This section changes its point of view from settlement members to third parties. Looking at third party gross settlement value reveals that the 5 largest third parties account for almost 40 percent of total third party value. Third party connectivity is clearly more divers than settlement member connectivity. The top 5 third parties show connectivity characteristics similar to settlement members. The majority, however, has only a few settlement members and even fewer third parties that they deal with. In average, third parties have five times more links to settlement members than to other third parties. Larger third parties also show more links to settlement members as well as to other third parties. The 34 third parties that were existent in each year from 2003 to 2006, in average had 14 connections to settlement members and only 2 to other third parties in 2003. In 2006, the average connection to settlement members almost doubled to 26 while the average connection to other third parties increased to 22. In a network context, this does not mean better connectivity because the number of tp-nodes increased significantly. The third party connectivity even decreased over the years which is well reflected in table 7.4. As noted earlier, the network statistics suggest that newer third parties are smaller in terms of settlement value. Supposition 6 explores this more closely. Looking at the gross value distribution in figure 7.2 makes clear that 90 percent of all third parties fall in the first gross value decile. Calculating the percentage of new third parties that show gross values larger than 100 billion USD results in 11 percent for 2004, 6 percent for 2005, and 1 percent for 2006. This means that of all the new third parties in 2006, only 1 percent has a gross settlement value of more than 100 billion USD. A comparison of former years suggests a confirmation of **supposition 6**. It seems that new third parties tend to be smaller in value. Even though, the majority of third parties is considerably smaller in value and degree than most settlement members, there are a few with connectivity characteristics similar to settlement members. In an isolated network context there is no obvious reason for them not become settlement members. In summary, the relationship structure of settlement members is more homogeneous compared to the set of third parties.

7.8 Chapter Summary

This chapter explores the trade relations among settlement members and third parties based on their CLS gross settlement value. To gain insights into the relationship structure, descriptive statistics as well as specific network statistics are applied. Except the distribution of settlement member relationships to third parties, the distribution of all other relationships show power law characteristics. This means that there is a small group of settlement members and third parties that account for a large portion of relationships and generate a major fraction of total settlement value. It is important to understand that these relationships do not reveal any information regarding settlement arrangements on an operational level.

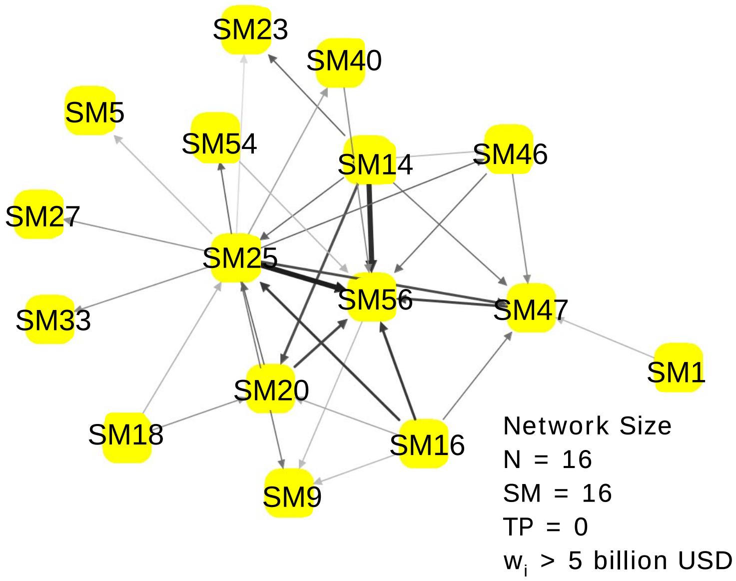

Figure 7.6: Network in April 2003.

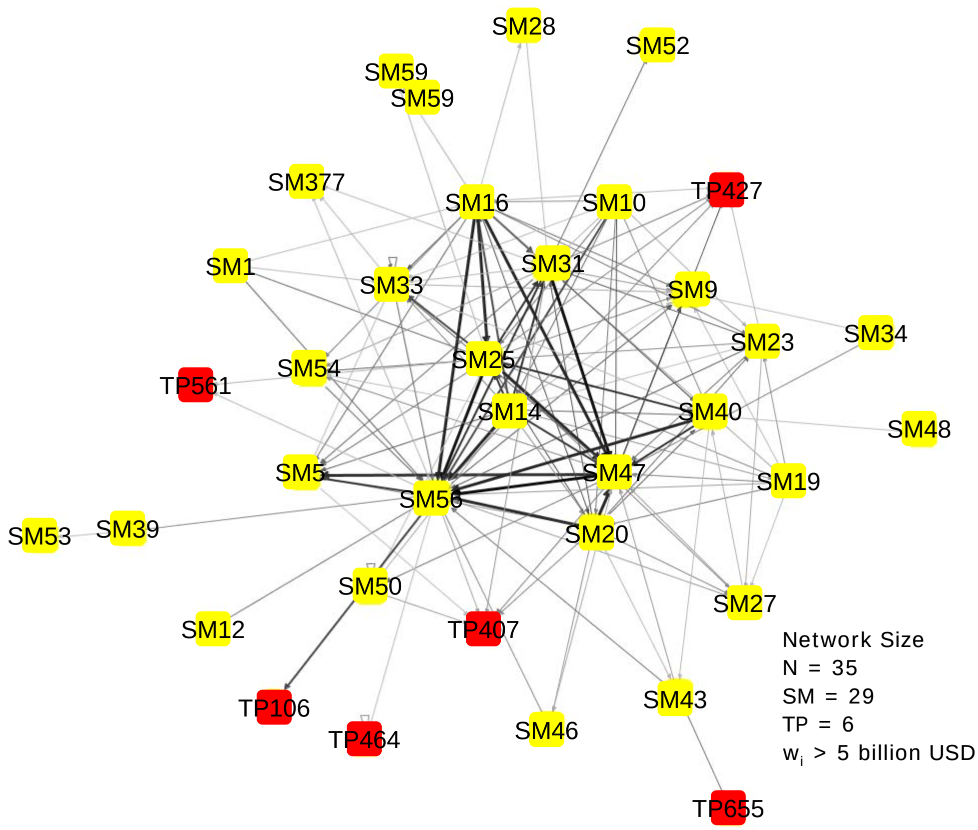

Figure 7.7: Network in April 2006 (I).

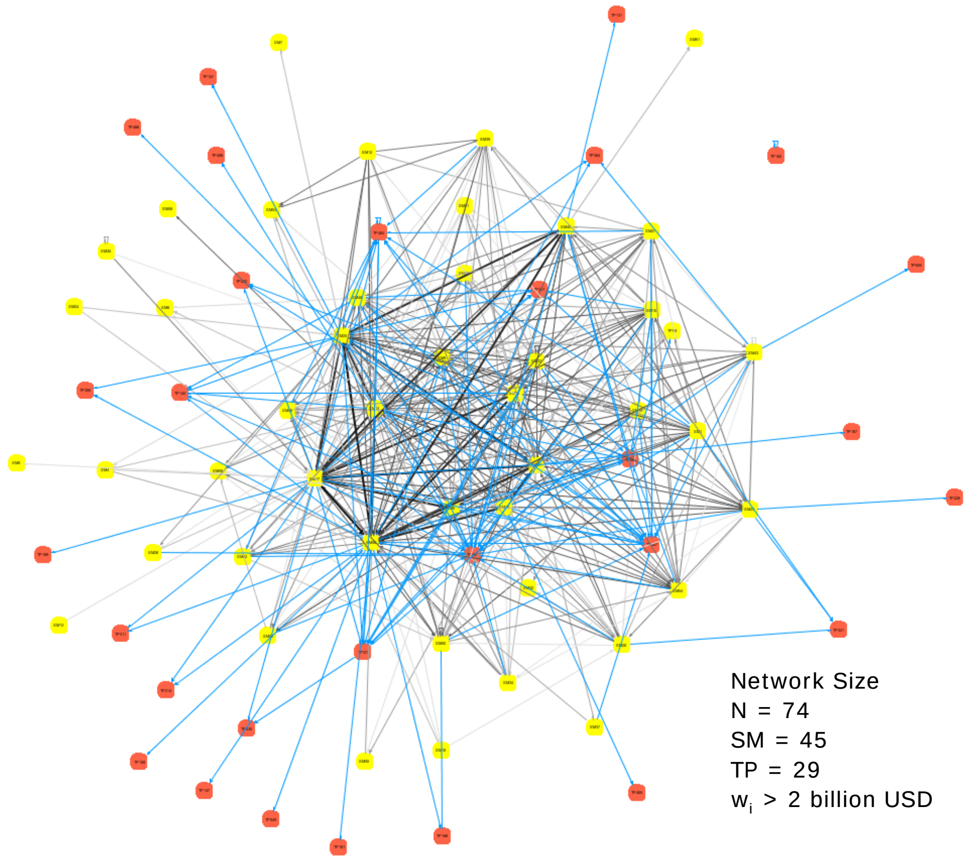

Figure 7.8: Network in April 2006 (II).

Chapter 8

Liquidity Aspects

8.1 Introduction

Liquidity issues are one of the main topics today when it comes to clearing and settlement processes. Due to its net funding mechanism, CLS requires only 2 to 3 percent liquidity of gross settlement value to be paid in. Even though this is a substantial netting performance, the cash amounts are still considerable. The basic problem arising with CLS is caused by the fact that not the entire world of possible counterparties settles their foreign exchange trades through CLS. Settlement members trade not only with other CLS members but also with counterparties that do not settle through CLS. This may cause an imbalance in liquidity needs during the funding hours of CLS and the funding hours of the traditional payment systems. A particular settlement member may have well balanced its trading books but still might experience a mismatch when it comes to settlement. Trades settling through CLS require funding early in the CET morning hours while the liquidity from non-CLS trades may only be available later that day. If the whole universe of counterparties would settle through CLS, this discrepancy would disappear. The net sell and buy positions of all settlement members would balance and funding could be minimized. Today, it is not clear by what the net positions of CLS participants are driven. Bilateral net positions among the participants vary widely day by day without any obvious reason. This chapter takes a closer look at these bilateral net positions. It looks for factors in the CLS participants' connectivity structure that may be identified as drivers for the level of these positions.

	SM1	**SM2**
trade 1	buy 100 USD	buy 75 EUR
	sell 75 EUR	sell 100 USD
trade 2	buy 50 EUR	buy 80 CHF
	sell 80 CHF	sell 50 EUR
trade 3	buy 150 EUR	buy 200 USD
	sell 200 USD	sell 150 EUR
sell EUR	75 EUR	200 EUR
sell USD	200 USD	100 USD
sell CHF	80 CHF	0 CHF
net sell EUR	0 EUR	125 EUR
net sell USD	100 USD	0 USD
net sell CHF	80 CHF	0 CHF
overall BNSP	168 USD	168 USD

Table 8.1: Calculation of Bilateral Net Sell Position.

8.2 Definition of Bilateral Net Sell Position

Additionally to the gross settlement value already used in chapter 7, chapter 8 introduces the so called bilateral net sell position (BNSP). It is the net sell value of all trades settled by a pair of settlement members and/or third parties on one day. An example illustrates the calculation of the bilateral net sell position. Consider two settlement members, SM1 and SM2, that settle three trades as summarized in table 8.1. To settle trade 1, SM1 needs to deliver 75 EUR and receives 100 USD. SM2 must deliver 100 USD and receives 75 EUR. The same mechanism is true for trade 2 and 3. For SM1 this is equal to a sell position of 75 EUR which implies that SM1 must theoretically come up with 75 EUR in liquidity at a specific time. SM2, in turn, must come up with 200 EUR in liquidity which results in a net sell position of 125 EUR for SM2. Converting it to dollar-equivalents results in an overall bilateral net sell position of 168 USD for SM2. Repeating this calculation for all currencies leads to net positions of 100 USD and 80 CHF for SM1. This corresponds to an overall BNSP of 168 USD for SM1. Neglecting currency fluctuations during the day, the bilateral net sell positions must always be equal. The bilateral net sell position may be interpreted as a driver for the amount of liquidity that must be delivered by the settlement members or third parties. It is important to understand that the bilateral net sell position is not equal to the net pay-in that has to be made by settlement members. The pay-ins are the effective net cash transfers (after possible in-out swaps or other netting arrangements) from the settlement members to CLS as described in 5.4.4. The net sell position, in contrast, is a calculatory dimension that reflects a CLS member's position in the market in terms of its trading activity. It is not a direct measure for liquidity needs. It merely indicates a settlement member's net sell position against other CLS participants. Using the cash pay-ins as a proxy for liquidity needs seems more straight forward. Yet, it would not allow for insights into the actual positions of the CLS participants. There are two main reasons for this: (1) third parties do not make any pay-ins. The pay-ins for third parties are accomplished by settlement members. Hence, pay-ins do not reflect the actual positions of the CLS members. In particular the liquidity positions for third parties could not be identified. (2) pay-ins do not reflect the underlying trade relations due to the in-out swap mechanism that generates trades only for netting purposes. The bilateral net sell position does not suffer from these two problems and is therefore considered as an adequate proxy for the CLS participant's liquidity positions. On the downside there is the argument that a theoretical liquidity position is not of much interest. It is only the actual liquidity that is of concern. But due to data availability constraints the bilateral net sell position is currently the best applicable measure. Table 8.2 summarizes the average, minimum, and maximum bilateral net sell position per day in million USD of the five largest settlement members and third parties (in terms of gross settlement value) in the first week of April 2006. In average, the bilateral net sell position is about 50 percent of gross settlement value. This is not only true for the month of April 2006 but also for April in former years. The average bilateral net sell position has increased in line with the average gross settlement value. The following analysis is therefore not focused on the development over time but on the cross sectional data for April 2006.

8.3 Regression Analysis

To identify a possible dependency between the CLS' participant connectivity structure and the level of bilateral net sell positions, regression analysis is applied. It is analyzed whether specific connectivity characteristics of CLS members lead to lower bilateral net sell positions. The degree serves as proxy for the specific connectivity characteristic of a member. It is defined as the

	mean	%	min	max
SM1	434	41%	0	15’700
SM2	405	40%	0	15’500
SM3	390	42%	0	7’900
SM4	417	45%	0	8’900
SM5	369	42%	0	13’400
TP1	392	35%	0	3’400
TP2	546	66%	0.2	2’100
TP3	590	75%	0	3’200
TP4	334	65%	0.6	1’000
TP5	179	36%	3	900

Mean, min, max in million USD equivalents. % = mean bilateral net sell position in percent of mean gross value.

Table 8.2: Bilateral Net Sell Positions in April 2006.

number of links from a particular node to all others. The higher the degree of a node in the network, the higher its connectivity. A formal definition of degree and network connectivity can be found in section 7.2. The regression analysis is based on four panel data sets including the four weeks of April 2006. The first data set includes 49’124 bilateral net sell positions from April 3 to April 7. The second set consists of 42’342 records between April 10 and April 14. The data set representing the third week of April includes 42’005 data records from April 17 to April 21, and the fourth week 49’002 from April 24 to April 28. The dependent variable is defined as the bilateral net sell position between a pair of CLS participants: $BNSP_i = Y_i$.

8.3.1 Basic Regression

As a first step, the following regression model is defined:

$$Y_i = \alpha + \beta_1 DEG_i + \beta_2 \Delta DEG_i^2 + \delta_1 SMD_i + \delta_2 TPD_i + \epsilon_i \tag{8.1}$$

i refers to the observed pair of settlement members or third parties that is involved in the respective bilateral net sell position. DEG_i is defined as the sum of the degrees of the two involved participants. This independent variable is expected to have a negative effect on the bilateral net sell position. This means that the higher the degree and therewith the connectivity of the involved parties, the lower the bilateral net sell position. The rational for

Regression I

	BNSP_{W1}	BNSP_{W2}	BNSP_{W3}	BNSP_{W4}
IC	-478.3***	-423.5***	-456.3***	-510.2***
	(-70.7)	(-59.1)	(-60.2)	(-68.6)
DEG	2.5***	2.2***	2.3***	2.6***
	(92.7)	(77.9)	(79.1)	(90.2)
ΔDEG^2	-3'230.6***	-2'881.2***	-2'848.6***	-3'293.5***
	(-27.8)	(-23.4)	(-21.9)	(-26.2)
SMD	103.3***	86.9***	103.2***	99.4***
	(23.2)	(18.5)	(20.7)	(20.2)
TPD	92.6***	88.6***	97.5***	101.2***
	(18.2)	(16.1)	(16.4)	(18.1)
Adj.R^2	0.24	0.20	0.21	0.22

t-statistics in parentheses.*** indicates statistical significance at a 1% level based on a two-sided test. Coefficients for IC, DEG, SMD, TPD in million. IC = intercept. BNSP_{Wi} = bilateral net sell position in week i of April 2006. DEG = sum of counterparties' degrees. ΔDEG^2 = squared difference of counterparties' degrees. SMD = relation type dummy equaling 1 if both counterparties are settlement members, zero otherwise. TPD = relation type dummy equaling 1 if both counterparties are third parties, zero otherwise.

Table 8.3: Basic Regression.

this expectation is the fact that a participant with higher connectivity has more counterparties within CLS that it can trade with. Its world of CLS trade partners is more complete than for a participant with low connectivity. The mismatch caused by the split between CLS trades and non-CLS trades should be smaller because a highly connected participant is less dependent on non-CLS trade partners. ΔDEG_i^2 is the squared difference between the connectivity of the two involved trade partners. This variable provides insights to whether or not large differences in connectivity of the two trading partners play a significant role regarding the level of bilateral net sell positions. While the variable DEG_i controls for the absolute level of connectivity, ΔDEG_i^2 isolates the effect of differences in the connectivity of the two trade partners. SMD_i and TPD_i are dummy variables that specify the type of trade relation. Three relations are possible: (1) a settlement member deals with a third party (sm-tp link). This combination type is defined as the control group. (2) a settlement member deals with a settlement member (sm-sm link). In that case the variable SMD_i equals 1 and zero otherwise. (3) a third party deals with a third party (tp-tp link). If this is true, TPD_i equals 1 and zero otherwise. Table 8.3 shows the results for the four weeks of this regression model. Each of the defined variables shows statistical significance at a high level. The degree variable does not, like expected, indicate a negative impact on the net sell position. In contrast, the degree difference variable shows a negative sign, indicating that the net sell position is smaller, the larger the difference in the degree of the two involved parties. This result is also unexpected. The two dummy variables show that the net sell position is larger in case of sm-sm links and tp-tp links compared to mixed links. The positive dependency between tp-tp links and the net sell position would be inline with what is expected. Namely, that the net sell position resulting from a relationship between two third parties would be larger than from a relationship between a third party and a settlement member, because latter involves at least one party that is highly connected. For the same reason, it would be expected that a relationship between two settlement member would result in a lower net sell position than between a settlement member and a third party. This is not confirmed by the sign of the SMD coefficient. In summary, the regression results are robust over the four different time periods, but do not reflect the expected dependencies. The results raise doubts regarding the adequacy of the model. It provokes the suspicion that the degree variable rather acts as a proxy for size than for connectivity. As described in chapter 7, degree and gross settlement value are correlated. Large participants in terms of gross value also show high degrees. Gross value, in turn, is highly correlated with the net sell position. These dependencies must somehow be excluded from the regression model to isolate the effect of connectivity. As a first step, the following section introduces an amended regression model that controls for the bilateral gross settlement value.

8.3.2 Controlled Regression

To exclude the size effect from the degree variable, the bilateral gross settlement value for each relationship is introduced as a control variable. The revised model looks as follows:

$$Y_i = \alpha + \beta_1 gv_i + \beta_2 DEG_i + \beta_3 \Delta DEG_i^2 + \\ + \delta_1 SMD_i + \delta_2 TPD_i + \epsilon_i \tag{8.2}$$

The regression results for this model are displayed in table 8.4. As expected, the control variable turns out to be significantly different from zero. The degree variable, however, does not loose its significance nor does it change its sign. The variable DEG_i still seems to have explanatory power, additionally to the bilateral gross value. The variable representing the degree difference as well as the two dummy variables neither change signs compared to the first regression model. The dependencies do not point to the direction that would be expected. The model still seems to be dominated by the size factor and is not able to isolate the effect of connectivity. It becomes clear that controlling for size by including the bilateral gross settlement position is not sufficient. In a second step, the size effect is therefore controlled by the sum of the aggregated gross settlement values of the involved parties. Additionally, connectivity is examined on a relative basis. To implement these ideas, a third regression model is introduced in the following section.

8.3.3 Relative Regression

The third regression model implements two improvements: (1) it adds an additional control variable to get rid of the size effect that overlays the connectivity effect and (2) it includes the degrees of a participant relative to its aggregated gross settlement value. The new control variable is named GV_i and is defined as the sum of the overall gross values that the two involved parties settled in the month of April 2006. In contrast to gv_i which is the bilateral gross settlement value of two parties on a specific day, GV_i more adequately reflects the actual size of the involved parties. The variable $RDEG_i$ is now defined as the sum of the relative degrees of the two involved parties. The term relative degree refers to the degree divided by the overall gross settlement value of that particular participant. Or in other words, the total gross value per link in April 2006. Correspondingly, $\Delta RDEG_i^2$ represents

Regression II

	BNSP_{W1}	BNSP_{W2}	BNSP_{W3}	BNSP_{W4}
IC	-72.3***	-52.2***	-47.5***	-51.2***
	(-16.6)	(-12.3)	(-10.6)	(-11.4)
gv	0.3***	0.3***	0.4***	0.4***
	(289.1)	(301.7)	(299.6)	(315.6)
DEG	0.5***	0.4***	0.3***	0.4***
	(27.4)	(21.8)	(19.5)	(21.6)
ΔDEG^2	-732.9***	-700.4***	-605.1***	-723.6***
	(-10.3)	(-10.0)	(-8.2)	(-10.0)
SMD	25.4***	23.2***	25.0***	13.1***
	(23.2)	(8.7)	(8.8)	(4.6)
TPD	9.0***	7.3***	6.5***	2.4
	(2.9)	(2.3)	(1.9)	(0.7)
Adj.R^2	0.72	0.75	0.75	0.74

t-statistics in parentheses.*** indicates statistical significance at a 1% level based on a two-sided test. Coefficients for IC, DEG, SMD, TPD in million. IC = intercept (in million USD). gv = bilateral gross settlement value. BNSP_{Wi} = bilateral net sell position in week i of April 2006. DEG = sum of counterparties' degrees. ΔDEG^2 = squared difference of counterparties' degrees. SMD = relation type dummy equaling 1 if both counterparties are settlement members, zero otherwise. TPD = relation type dummy equaling 1 if both counterparties are third parties, zero otherwise.

Table 8.4: Controlled Regression.

Regression III

	$BNSP_{W1}$	$BNSP_{W2}$	$BNSP_{W3}$	$BNSP_{W4}$
IC	5.3***	4.1**	7.1***	13.2***
	(2.8)	(2.2)	(3.6)	(6.7)
GV	0.0***	0.0***	0.0***	0.0***
	(20.1)	(16.0)	(13.9)	(13.0)
gv	0.3***	0.4***	0.4***	0.4***
	(283.5)	(296.1)	(293.1)	(309.1)
RDEG	-2'126.6***	-7'134.8***	-4'757.8***	-16'916.1***
	(-2.4)	(-3.5)	(-3.2)	(-4.6)
$\Delta RDEG^2$	0.0***	0.1***	0.0***	0.6***
	(2.4)	(3.0)	(3.0)	(3.3)
SMD	52.3***	45.2***	45.5***	36.9***
	(21.3)	(19.1)	(18.0)	(14.5)
TPD	6.2**	6.5**	5.3*	-1.2
	(2.0)	(2.1)	(1.6)	(-0.4)
Adj.R^2	0.71	0.74	0.75	0.74

t-statistics in parentheses.***, **, * indicate statistical significance at a 1%, 5%, 10% level based on a two-sided test. Coefficients for IC, SMD, TPD in million. IC = intercept. GV = gross settlement value in April 2006. gv = bilateral gross settlement value. $BNSP_{Wi}$ = bilateral net sell position in week i of April 2006. DEG = sum of counterparties' degrees. ΔDEG^2 = squared difference of counterparties' degrees. SMD = relation type dummy equaling 1 if both counterparties are settlement members, zero otherwise. TPD = relation type dummy equaling 1 if both counterparties are third parties, zero otherwise.

Table 8.5: Relative Regression.

the squared difference of the two relative degrees. The bilateral gross value variable gv_i has been retained unchanged. The new model can be described as:

$$Y_i = \alpha + \beta_1 GV_i + \beta_2 gv_i + \beta_3 RDEG_i + \beta_4 \Delta RDEG_i^2 + \\ + \delta_1 SMD_i + \delta_2 TPD_i + \epsilon_i \quad (8.3)$$

Looking at table 8.5 shows that on a 99 percent confidence level, the relative degree variable as well as the relative degree difference variable changed their signs. The variable GV_i differs significantly from zero and seems to effectively control for size. The degree expressed on a relative basis is finally no longer correlated to size in terms of gross value. The revised model mostly reflects what was expected. The relative degree of the two involved parties has a negative effect on the net sell position. This implies that the higher the connectivity of the related parties in relation to their gross settlement values, the lower their bilateral net sell positions. The reason for this dependency being plausible was already explained in 8.3.1. Better connected participants have more counterparties within CLS to trade with. They are less dependent on trade partners outside CLS. The imbalance between inside and outside CLS trades might thus be lower than for participants with low connectivity inside CLS. The negative coefficient for the variable $RDEG_i$ describes this dependency, though on a relative basis. The relative degree difference $\Delta RDEG_i^2$ turns out to have a positive effect on the net sell position. This suggests that the larger the difference of the relative degrees of the two involved parties, the larger their bilateral net sell position. A relationship between two parties with low relative degrees generates a lower net sell position than a mixed relationship. The same is true for a relationship between two parties with high relative degrees. The SMD variable did not change its sign. It suggests that a sm-sm relationship generates larger net sell positions compared to a mixed relationship. As this variable cannot be adjusted on a relative basis as was done with the degree variables it should only be accepted with reservation. It is likely that the variable is simply stamped by the size effect explained earlier. Compared to the relationships between two third parties, the relationships between two settlement members generally involve much higher gross settlement values and with that, also much higher net sell positions. The same considerations are applicable for the TPD variable. On a 99 percent confidence level, TPD is not significantly different from zero. The two dummy variables, therefore, might better be interpreted with caution. Recalling the fact, that in average the bilateral net sell positions relative to the gross settlement values did not change during the past years, suggests that simply increasing the number of participants does not lower the bilateral net sell positions. This, combined with the regression results might indeed indicate that there is a cross sectional relation between the level of bilateral net sell positions and the structure of trade partners. In summary, the third model might bring up the idea that there could be an optimal level of relative connectivity that would minimize the net sell position, at least theoretically. In practice, an optimal level of relative connectivity would be restricted by the maximum number of participants. Large members might not be able to reach this theoretically optimal level of relative connectivity. Furthermore, it should be questioned whether such an optimal level is of interest at all. As mentioned earlier, the net sell position does not represent the actual liquidity needs. The use of its optimization is therefore unclear. Equally unclear is the question whether a minimized bilateral net sell position would in fact lead to lower liquidity needs.

8.4 Chapter Summary

The bilateral net sell position is defined as the net sell value of all trades settled by a pair of settlement members and/or third parties on one day. These positions vary significantly day by day without any obvious reasons. This chapter looks for factors in the CLS participants' connectivity structure that may drive these positions. Using regression analysis, some dependencies between the level of connectivity and the corresponding level of net sell positions can be shown. Connectivity in relation to gross settlement value has a negative effect on net sell positions, meaning that the better the connectivity of a participant compared to its size in terms of gross settlement value, the lower its net sell positions. Besides the relative connectivity of the participants, also the difference in connectivity of the trade partners seems to drive net sell positions. Regression results suggest, that trade relationships involving two parties with a large difference in their connectivity, lead to higher net sell positions. These interpretations are in line with what was expected. A highly connected CLS participant has more counterparties within CLS that it can trade with and is assumed to be less dependent on counterparties outside CLS. The imbalance caused by the split between CLS trades and non-CLS trades should be smaller for this particular participant. This, in turn, is likely to result in lower levels of liquidity needs. In summary, the analysis empirically shows that specific connectivity characteristics of trade relationships have an effect on the level of bilateral net sell positions.

Chapter 9

Conclusion

Today, the so called Allsopp-Report (p. 42) is widely interpreted as a threat from the Bank for International Settlements to the industry. It urged industry players and regulatory authorities to reduce credit risk in foreign exchange settlement. A group of key players, the G20, affiliated to take action. The result was a complex IT project that was more than once at the verge of capitulation in its childhood. Merely the scope of engagement did not allow for failure. Remarkable efforts and painful trade-offs were necessary to bring the system alive. Today, after five years of operation, the system can be considered as the settlement industry's standard in foreign exchange. Though, CLS is a success story, future projects may learn from its history. The complexity of the project was crucial. With hindsight, the integration of existing platforms would probably have proven to be more efficient than building a new system from scratch. Staff changes complicated the project's continuity and aggravated the emotional relationships among the affected parties. Involvement of numerous central banks, different authorities, and legislations turned the project into a sensitive and also political affair. At some points, intervention by the Bank for International Settlements was vital. It is clear that enormous risks are inherent to an IT project of this scale. Measuring and controlling these risks is equally difficult and important. It may be assumed that without the right dose of pressure from a powerful authority at the right time, the project may have perished of its own complexity. Once running, the system proved its resilience and was able to successfully penetrate the market. Around 60 percent of global foreign exchange turnover is estimated to be settled in CLS. If this equals a 60 percent credit risk reduction, the urge of the Bank for International Settlements may be considered to be well fulfilled. Though CLS' market share is still increasing there will be a limit as long as not the whole world of possible foreign exchange trade partners participates in CLS. It is yet not clear, whether one day CLS participation will be crucial to find counterparties that are willing to enter a trade. So far, there is no price segmentation (in terms of currency rates) depending on where the trade gets settled and it is unlikely that this will happen in the future. Segmentation is enforced by value and volume limits. Counterparties that do not settle in CLS already experience unfavorable conditions regarding trade limits. This effect may intensify in the future. CLS's mechanism minimizes liquidity needs for settling its transactions, but at the same time imposes new restrictions on liquidity provisions. The exact timing of pay-ins is unique in the settlement industry and bears new challenges. CLS was aware of the arising difficulties and reacted with the introduction of the so called in-out swaps (p. 91). Despite being planned as a temporary solution, in-out swaps became an essential tool for liquidity management. It is unclear, whether it is possible or even desirable to replace the in-out swap mechanism in future. Ideas such as cross-boarder cash pools and the extension of CLS' settlement window are in the air and seem to offer promising improvements compared to current liquidity management. Broad implementations, however, will take time and presumably require financial and/or authoritative pressure just as it was the case for CLS itself. The empirical part of the thesis offers insights into the trading structure among CLS members. Substantial differences in the structure of settlement member and third party relationships were found. Settlement members are highly connected among each other and do not show significant changes over time. The connectivity of third parties is much lower and shows the development of power law characteristics. Statistics and visualized network graphs suggest that new third parties tend to be smaller than the existing ones. This means that a relatively small group of members generates an increasing part of the business. In terms of liquidity, the analysis was based on the bilateral net sell position. The fact that these positions did in average not lower during the past years, indicates that simply increasing the number of members does not automatically lead to lower bilateral net sell positions. In contrast, cross sectional regression suggests that there is a certain dependency between the level of the bilateral net sell position and the type of trade relation. It seems that trade relations between members with high relative connectivity lead to lower bilateral net sell positions. If and how these results may be implemented in a practical context is yet unclear.

9.1 Critique and Further Research

Liquidity is a key issue in settlement. Its management is complex, costly, and vital for systemic stability. Academics, however, have just started to focus on these topics. Lack of data might be an important reason for this research area to be underdeveloped. The acquisition of the data that was presented in these chapters was a challenging task. Data protection and editing do not allow for open access. Consequently, the research design of this thesis was decisively stipulated by data availability which in general is not a desirable starting point. Three main issues of serious criticism arise with this dependency: (1) As the historical part of the thesis is based on original CLS documents, it widely ignores the notions of individual banks and IT service providers that were involved in the project. It documents CLS's history from a one-sided view. (2) The data set presented in chapter 7 is enclosed in itself an cannot be related to the outside world of CLS. It frustrates a comprehensive analysis of the CLS trade structure compared to the non-CLS trade structure and does not even allow for insights into the structure of third party service providers. It would have been interesting to explore the structural development of inside- and outside CLS transactions and in particular the development of third party service providers. As addressed by industry professionals, a consolidation process is assumed to be going on. Smaller institutions that are active in foreign exchange trading seem to reduce their number of correspondent banking relations and concentrate on a few "one-stop" service providers. If this is true, CLS might be identified as an important driver for such a development. The thesis on hand, due to lacking data, is not able to provide such insights. (3) Chapter 8 suffers from similar problems. Instead of analyzing the dependency between the trade structure and actual liquidity needs, a proxy had to be employed. Consequently, the interpretation of the results is not quite clear. Despite of, or even because of the critique, this thesis intends to motivate further research on the issues mentioned above. Altogether, the thesis contributes to the academic literature in that it provides a sound and unique approach to the world of Continuous Linked Settlement.

9.2 Food for Thought to Practitioners

Continuous Linked Settlement is a topic that is of interest particularly to practitioners. As the setting of the empirical chapters 7 and 8 rather treats theoretical aspects of CLS' settlement member structure, this section intends to provide food for thought to practitioners. In the wake of the network analysis in chapter 7, it appears that there is no distinct difference in the structural importance of settlement members and third parties. In other words, some system participants with the status of third parties exhibit equal or even larger trade values than some of the settlement members. Intuition would suggest that the status of being a settlement member is reserved for large participants. Accordingly, a third party status would be appropriate for smaller participants. Figure 7.8 does not support this intuition. There is more than a dozen of third parties that seem to be at least equally large in trade value than most settlement members. Two explanations are conceivable: (1) compared to a settlement member status, a third party status is more attractive in terms of cost. As a consequence, there might be third parties that from a business point of view would better be classified as settlement members. (2) The third parties in question do not meet certain criteria requested by CLS to become settlement members. Both points might lead to a bias in the participant structure. It is obvious that system stability requires adequate risk profiles for settlement members. The second reason for large participants not becoming settlement members might therefore be well acceptable. But third parties that are prevented from applying for settlement member status due to cost issues might scale down CLS' business. In that case, reconsidering CLS' cost structure might be worthwhile. A starting point for further investigations on this topic could be the idea of an optimal classification scheme for third parties and settlement members, including the relevant cost issues for both, CLS and its members. Results might help to design a cost structure that would entice certain third parties to become settlement members. Considering the difficulties arising with the split of CLS- and non-CLS trades (chapter 8), it should not exclusively be the interest of CLS Bank to increase the number of its members. It is likely that also the industry could benefit from an increased number of participants, especially in terms of liquidity management.

Appendix A

Keyword Index

Aggregate Short Position Limit (ASPL) CLS risk management rule that places a cap on the sum of a settlement member's short positions. (p. 87)

Allsopp-Report Report published by the Bank for International Settlements on "Settlement Risk in Foreign Exchange Transactions" in 1996. Set the basis for the foundation of CLS. (p. 42)

Bilateral Net Sell Position (BNSP) Net sell value of all trades settled by a pair of settlement members and/or third parties on one day. (p. 132)

BOJ-NET Real-time gross settlement system of Japan. (p. 21)

BOK-Wire Bank of Korea Financial Wire Network. Real-time gross settlement system of Korea. (p. 22)

CCP Central counterparty. Settlement institution that provides clearing and guarantees the execution of transactions. (p. 6)

CFD Contract for differences. Derivative products that allow traders to settle foreign exchange transactions without principal payments. (p. 14)

CHAPS Clearing House Automated Payment Service. Real-time gross settlement system of the United Kingdom. (p. 18)

CHATS Clearing House Automated Transfer System. Real-time gross settlement system of Hong Kong. (p. 21)

CHIPS Clearing House Interbank Payment System. US net settlement system. (p. 17)

Connectivity Network Analysis. Number of links of a node in relation to the number of possible links that node could have in the network. (p. 108)

Cumulative Distribution Function $P(k)$ Network Analysis. Represents the probability that the degree of a node is greater or equal to k. Degree data is best presented by a plot of the cumulative Distribution Function. (p. 109)

Degree k_i Network Analysis. The degree of a node is the number of links connected to that particular node. Links may be directed or undirected. (p. 108)

Degree Distribution $p(k)$ Network Analysis. Probability distribution that a particular node has exactly degree k. It is a function describing the total number of nodes with a given degree. (p. 108)

ESAS Exchange Settlement Account System. Real-time gross settlement system of New Zealand. (p. 22)

Fedwire US real-time gross settlement system. (p. 17)

G20 Group of 20. Group of senior bankers from large international financial institutions with common interest regarding large value cross-border payments. (p. 47)

Herstatt Risk Synonym for credit risk in settlement. Referring to the collapse of Bankhaus Herstatt. (p. 33)

In-Out Swap CLS liquidity management tool. Combination of two foreign exchange swaps in opposite directions. One trade is settled in CLS. With that trade, settlement members sell long positions and buy short positions. The second trade is an exact mirror image of the first trade but settles outside CLS. (p. 91)

KRONOS Real-time gross settlement system of Denmark. (p. 21)

Liquidity Provider CLS risk management facility. Liquidity providers are settlement members that commit to provide liquidity in a certain currency in case other members fail to meet their pay-in obligations. (p. 88)

LVTS Large Value Transfer System. Real-time gross settlement system of Canada. (p. 20)

MEPS+ Monetary Authority of Singapore Electronic Payment System. Real-time gross settlement system of Singapore. (p. 23)

NBO Norges Bank's Settlement System. Real-time gross settlement system of Norway. (p. 22)

Net Positive Overall Value (NPOV) CLS risk management rule ensuring self collateralization. It is met when the mark-to-market value of a settlement member's aggregated long currency position is more than the aggregate of the mark-to-market values of its short positions. (p. 85)

Net Settlement Settlement of a number of obligations or transfers between or among counterparties on a net basis. (p. 9)

Netting Process of transmitting, reconciling and, in some cases, confirming payment orders or security transfer instructions prior to settlement, possibly including the netting of instructions and the establishment of final positions for settlement. (p. 5)

Network Set of items (nodes) with connections between them (links). Networks that can be observed in the real world are often called real world networks. (p. 107)

Nostro Agent Are connected to their local real-time gross settlement system and transfer pay-ins to CLS in lieu of settlement members. A nostro agent is not a participant of CLS. (p. 76)

Pay-Ins Funds transferred by settlement members to CLS according to a pre-defined schedule during the morning hours of Central European Time. (p. 81)

Pay-Outs Funds transferred from CLS to its settlement members. Within the constraint of certain risk parameters, pay-outs are made throughout the settlement process. CLS pays out any long balances whenever settlement is successfully completed. (p. 84)

PvP Payment versus payment. funds of two counterparties are transferred simultaneously and are only considered final if the counter-transfer is final as well. (p. 6)

RITS Reserve Bank Information and Transfer System. Real-time gross settlement system of Australia. (p. 19)

RIX Real-time gross settlement system of Sweden. (p. 23)

RTGS Real-time gross settlement. Continuous settlement of funds or securities transfers individually on an order by order basis without netting. (p. 8)

SAMOS South African Multiple Option Settlement System. Real-time gross settlement system of South Africa. (p. 23)

Settlement Discharge of obligations of buyer and seller through the transfer of funds and/or securities. (p. 5)

Settlement Finality Assurance that at some point transfer of payments is complete, irrevocable and unconditional. (p. 6)

Settlement Member (SM) CLS participant with direct access to the system. (p. 74)

Settlement Risk Risk stemming from payment system participants' failure to fulfill their obligations on time. May be split in credit risk, liquidity risk, market risk, operational risks and legal risks. (p. 31)

Short Position Limit (SPL) CLS risk management rule ensuring a maximum short position for all settlement members in a particular currency. (p. 86)

SIC Swiss Interbank Clearing. Real-time gross settlement system of Switzerland. (p. 19)

Strength s_i Network Analysis. The strength of a node is the sum of all weighted links that are connected to that particular node. (p. 108)

SWIFT Society for Worldwide Interbank Financial Telecommunication. Service provider who supplies standardized messaging services. (p. 24)

TARGET Trans-European Automated Real-time Gross settlement Express Transfer. Real-time gross settlement system for the central banks of the European Union. (p. 18)

Third Party (TP) CLS participant that has no direct access to the system. Submission of instructions and settlement is managed by a settlement member on behalf of the third party. (p. 76)

Undirected Network Network with links that do not show a particular direction between two nodes. (p. 108)

User Member CLS participant that directly sends instructions to the system but settles via the account of a settlement member. Today, CLS has only one user member. (p. 75)

Weighted Network Network with links that have weights w_{ij} (e.g. transaction values) attached to themselves. In an unweighted network, links are either existent or non-existent. (p. 108)

Appendix B

CLS Key Figures

	2006	2005	2004	2003	2002
Total assets	104.3	100.8	96.1	96.1	100.3
Total equity	33.5	28.0	30.1	44.2	72.2
Net income	-2.2	-2.1	-19.4	-35.1	-57.8
in million GBP, source: www.bankscope.com.					
Shareholders	68	68	68	69	69
Employees	166	155	154	141	n/a
SM	54	57	54	53	n/a
TP	391	257	118	36	n/a
source: www.bankscope.com and CLS.					
Settlement value	2'700	2'099	1'460	850	n/a
Instructions	250'000	180'000	135'000	70'000	n/a
average daily numbers, two-sided, source: CLS and own estimates.					

Table B.1: CLS Key Figures.

Bibliography

Albert, Réka & Albert-László Barabási (2000), 'Error and Attack Tolerance of Complex Networks', *Nature* **406**, 378–382.

Albert, Réka & Albert-László Barabási (2002), 'Statistical Mechanics of Complex Networks', *Reviews of Modern Paysics* **74**, 47–97.

Albert, Réka, Hawoong Jeong & Albert-László Barabási (1999), 'Diameter of the World-Wide Web', *Nature* **401**, 130–131.

Angelini, Paolo & Curzio Giannini (1993), On the Economics of Interbank Payment Systems, Termi di discussione del Servicio di Studi, No 193, Banca d'Italia, Rome.

Australian Payments Clearing Association (2004), 'APCA Annual Report 2004', http://www.apca.com.au.

Bank of Canada (2006), 'Payments and Other Clearing and Settlement Systems', http://www.bankofcanada.ca.

Bank of Japan (2006), 'Japan's Next-Generation RTGS', Payment and Settlement Department.

Bank of Korea (2006), 'Payments Systems in Korea', http://www.bok.or.kr.

Barabási, Albert-László & Réka Albert (1999), 'Emergence of Scaling in Random Networks', *Science* **286**, 509–512.

Barthélemy, Marc, Alain Barrat, Romualdo Pastor-Satorras & Alessandro Vespignani (2005), 'Characterization and Modeling of Weighted Networks', *Physica A* **346**, 34–43.

Battiston, Stefano, Eric Bonabeau & Gérard Weisbuch (2003), 'Decision Making Dynamics in Corporate Boards', *Physica A* **322**, 567–582.

BBC (2005), 'Nick Leeson and Barings Bank', Crime Case Closed, http://www.bbc.co.uk.

BCBS (2000), 'Supervisory Guidance for Managing Settlement Risk in Foreign Exchange Transactions', Basel Committee on Banking Supervision.

Bech, Morten & Kimmo Soramki (2001), Gridlock Resolution in Interbank Payment Systems, Discussion Paper 9, Bank of Finland.

BIS (1989), Report on Netting Schemes, Angell-Report, Group of Experts on Payment Systems.

BIS (1993), 'Payment Systems in the Group of Ten Countries', Bank for International Settlements.

BIS (1996), BIS, Technical report, Banking Application Department, New York, dated: 22 October 1996.

BIS (1997), 'Real-Time Gross Settlement Systems', Bank for International Settlements.

BIS (1999), 'Payment Systems in Australia', Bank for International Settlements.

BIS (2003*a*), 'Payment System in the Euro Area', Red Book, Bank for International Settlements.

BIS (2003*b*), 'Payment Systems in Canada', Red Book, Bank for International Settlements.

BIS (2003*c*), 'Payment Systems in Hong Kong', Red Book, Bank for International Settlements.

BIS (2003*d*), 'Payment Systems in Japan', Red Book, Bank for International Settlements.

BIS (2003*e*), 'Payment Systems in Singapore', Red Book, Bank for International Settlements.

BIS (2003*f*), 'Payment Systems in Switzerland', Red Book, Bank for International Settlements.

BIS (2003*g*), 'Payment Systems in the United Kingdom', Red Book, Bank for International Settlements.

BIS (2003*h*), 'Payment Systems in the United States', Red Book, Bank for International Settlements.

BIS (2007), 'Triennual Central Bank Survey, Foreign Exchange and Derivatives Market Activity in April 2007', Bank for International Settlements, Publications.

Boss, Michael, Helmut Elsinger, Martin Summer & Stefan Thurner (2003), 'The Network Topology of the Interbank Market', eprint arXiv:cond-mat/0309582.

Breeden, Richard (1990), Statement Before the Committee on Banking, Housing and Urban Affairs, United States Senate, Concerning the Bankruptcy of Drexel Burnham Lambert.

CBR Online (2006), SIA wins Bid for Real-Time Gross Settlement System in Norway, Computer Business Review Online, http://www.cbronline.com.

CLS (1995*a*), 'Creation of a PvP Solution to Foreign Exchange Settlement Risk', G20 Meetings, december.

CLS (1995*b*), 'G20 Meeting on 22 May', G20 Meetings, 20 june.

CLS (1995*c*), 'G20 Meeting on 27 February', G20 Meetings, 24 march.

CLS (1995*d*), 'Operational Feasibility Working Group', G20 Meetings, 23 october.

CLS (1995*e*), 'The Steering Group on Settlement Risk in Foreign Exchange Transactions', G20 Meetings, 21 june.

CLS (1996*a*), 'Business Case: Continuous Linked Settlement', Chase Manhattan Bank, 17 october.

CLS (1996*b*), Continous Linked Settlement System, Technical report, 17 december.

CLS (1996*c*), 'G20', G20 Meetings, 7 january.

CLS (1996*d*), 'G20', 16 january.

CLS (1996*e*), 'G20', G20 Meetings, 1 may.

CLS (1996*f*), 'G20 Conference Call', G20 Meetings, 15 march.

CLS (1996*g*), 'G20 Meeting on 1, 2 February', G20 Meetings, 13 february.

CLS (1996*h*), 'G20 Meeting on 2, 3 May', G20 Meetings, 29 april.

CLS (1996*i*), 'G20 Meeting on 2 December', G20 Meetings, 9 december.

CLS (1996*j*), 'G20 Meeting on 2,3 May', G20 Meetings, 16 may.

CLS (1996*k*), 'G20 Meeting on 25, 26 July', G20 Meetings, 9 august.

CLS (1996*l*), 'G20 Meeting on 9, 10 October', G20 Meetings, 11 november.

CLS (1996*m*), 'Liquidity Review with Fed', G20 Meetings, 12 january.

CLS (1996*n*), 'Meeting with Fed', G20 Meetings, 8 february.

CLS (1996*o*), 'Responses of Local Counsel to Request for Proposal', G20 Meetings, 26 september.

CLS (1996*p*), 'The Continuous Linked Settlement Model as a PVP Solution to Foreign Exchange Settlement Risk', G20 Meetings, march.

CLS (1997*a*), 'Admission Committee Meeting', CLS Services Ltd., 17 october.

CLS (1997*b*), 'Board of Directors Meeting', CLS Services Ltd., 22 november.

CLS (1997*c*), 'CLS Bank Membership Criteria', G20 Meetings, 28 january.

CLS (1997*d*), 'CLS Remote Access Subproject: Central Bank Questionnaire', 7 april.

CLS (1997*e*), Continuous Linked Settlement, Technical report, 15 january.

CLS (1997*f*), 'Continuous Linked Settlement Procurement Strategy', G20 Meetings, 5 june.

CLS (1997*g*), 'Development and Implementation of CLS', G20 Meetings, january.

CLS (1997*h*), 'G20', G20 Meetings, 10 march.

CLS (1997*i*), 'G20', G20 Meetings, 6 february.

CLS (1997*j*), 'G20 - Domestic Impact of CLS, RTGS Access Requirements of CLS Bank', 19 january.

CLS (1997*k*), 'G20 Economic Analysis', G20 Meetings, june.

CLS (1997*l*), 'G20 Meeting of 17, 18 April', G20 Meetings, 24 april.

CLS (1997*m*), 'G20 Meeting on 17, 18 June', G20 Meetings, 30 june.

CLS (1997*n*), 'G20 Meeting on 5 February', G20 Meetings, 19 february.

CLS (1997*o*), 'G20 Remote Access Project', 24 march.

CLS (1997*p*), 'Income and Expenditure Statement May to December 1996', G20 CLS Project, 20 january.

CLS (1997*q*), 'Joint ECHO/Multinet Proposal to the G20 Banks', ECHO/Multinet, 17 june.

CLS (1997*r*), 'Legal Survey of G10 Jurisdictions', 19 january.

CLS (1997*s*), 'Meeting of the Board of Directors', CLS Services Ltd., 18 september.

CLS (1997*t*), 'Proposed Structure and Responsibilities of the CLS Service Board Committees Post Merger', CLS Services Ltd., 17 october.

CLS (1997*u*), 'The Quantitative Analysis of the CLS', G20 Meetings, 29 january.

CLS (1997*v*), 'Various Initiatives to Reduce FX Settlement Riks', G20 Meetings, 23 january.

CLS (1998*a*), 'Admissions Committee Meeting', CLS Services Ltd., 2 march.

CLS (1998*b*), 'Annual Report and Accounts', CLS Services Ltd., 30 june.

CLS (1998*c*), 'Board of Directors Meeting', CLS Services Ltd., 3 may.

CLS (1998*d*), 'Business Plan', CLS Services Ltd., 16 april.

CLS (1998*e*), 'CLS Program Management, Progress Report', CLS Services Ltd., 15 january.

CLS (1998*f*), 'ECHO Business Options', CLS Services Ltd., 19 october.

CLS (1998*g*), 'ECHO Business Plan', CLS Services Ltd., 11 november.

CLS (1998*h*), 'Financial Performance and Control Report', CLS Services Ltd., 30 september.

CLS (1998*i*), 'Netting Integration', CLS Services Ltd., 26 january.

CLS (1998*j*), 'Press Release: CLSS Announces 24 New Shareholder as a Result of Successful Capital Raising Programme', CLS Services Ltd., 14 july.

CLS (1998*k*), 'Press Release: CLSS Announces Appointment of IBM to Build CLS Bank System and Details of its Development Programme', CLS Services Ltd., 27 april.

CLS (1998*l*), 'SWIFT and IBM Contract Briefing', CLS Services Ltd., 22 june.

CLS (1999*a*), 'Chairman's and Chief Executive Officer's Report, Reports and Accounts', CLS Services Ltd., 30 june.

CLS (1999*b*), 'CLS Bank International (in Formation), Financial Projections and Proposed Capitalization Structure', CLS Bank International, 1 june.

CLS (1999*c*), 'Extraordinary General Meeting of CLS Services Ltd. on the ECHO Status', CLS Services Ltd., 17 march.

CLS (1999*d*), 'IBM Software Build Cost', CLS Services Ltd., 29 january.

CLS (1999*e*), 'Joint CLSS/ECHO Special Board of Directors Meeting, Review of Netting', CLS Services Ltd., 4 february.

CLS (1999*f*), 'Liquidity Issue', CLS Bank International, 13 august.

CLS (1999*g*), 'Meeting of the Board of Directors', CLS Services Ltd., 19 june.

CLS (1999*h*), 'Private Placing of Shares', CLS Services Ltd., december.

CLS (2000*a*), 'CLS Board Meeting', CLS Services Ltd., 17 february.

CLS (2000*b*), 'Meeting of the Board of Directors', CLS Services Ltd., 7 september.

CLS (2000*c*), 'Meeting of the Board of Directors', CLS Services Ltd., 29 november.

CLS (2000*d*), 'Meeting of the Board of Directors', CLS Services Ltd., 16 december.

CLS (2000*e*), 'Memorandum to the Members of the Board of Directors', CLS Services Ltd., 27 june.

CLS (2000*f*), 'Presentation to the Board', Earnst & Young, 7 may.

CLS (2000*g*), 'Report on Accounts', CLS Services Ltd., 30 june.

CLS (2000*h*), 'Special Board of Directors Meeting', CLS Services Ltd., 24 april.

CLS (2001*a*), 'Board of Directors Meeting', CLS Services Ltd., 21 june.

CLS (2001*b*), 'Board of Directors Meeting', CLS Services Ltd., 13 september.

CLS (2001*c*), 'Risk Assessment Update', CLS Services Ltd., 24 january.

CLS (2001*d*), 'Testing and Live Trials Overview', CLS Services Ltd., 3 march.

CLS (2002*a*), 'Baord of Directors Meeting', CLS Services Ltd., 27 september.

CLS (2002*b*), 'Board of Directors Meeting', CLS Services Ltd., 21 march.

CLS (2002*c*), 'Board of Directors Meeting', CLS Services Ltd., 28 september.

CLS (2002*d*), 'Board of Directors Meeting', CLS Services Ltd., 16 august.

CLS (2002*e*), 'Board of Directors Meeting', CLS Services Ltd., 20 june.

CLS (2002*f*), 'Board of Directors Meeting', CLS Services Ltd., 24 november.

CLS (2002*g*), 'Corporate Restructuring of the CLS Group', CLS Services Ltd., 17 january.

CLS (2002*h*), 'Federal Reserve White Paper on Resilience, Directors Meeting', CLS Services Ltd., 14 november.

CLS (2002*i*), 'Managing Intraday Liquidity: A Brave New World', CLS Bank International, april.

CLS (2002*j*), 'Programme Update', CLS Services Ltd., 11 january.

CLS (2002*k*), 'Summary of IBM's Delivery Performance', CLS Services Ltd., 9 august.

CLS (2003*a*), 'Amendment No. 1 to the CLS Bank Foreign Exchange Liquidity Agreement', CLS Bank International, 24 june.

CLS (2003*b*), Annual Report and Consolidated Accounts, Corporate Governance Statement, CLS Group Holdings AG, 31 december.

CLS (2003*c*), 'Board of Directors Meeting', CLS Services Ltd., 20 june.

CLS (2003*d*), 'Board of Directors Meeting', CLS Services Ltd., 18 april.

CLS (2003*e*), 'Chief Executive's Report', CLS Services Ltd., 13 february.

CLS (2003*f*), Loss Allocation following a Liquidity Provider Fail, Liquidity Review Task Force, CLS Bank International, 6 may.

CLS (2003*g*), 'Meeting of the Risk Management Committee', CLS Bank International, may.

CLS (2003*h*), 'Strategic Plan 2003 - 2007', CLS Services Ltd., 3 february.

CLS (2004*a*), Annual Report and Consolidated Accounts, Corporate Governance Statement, CLS Group Holdings AG, 31 december.

CLS (2004*b*), 'Director Induction Pack', CLS Services Ltd., 29 april.

CLS (2004*c*), 'Directors Manual, Regulator's Summary', CLS Bank International, april.

CLS (2004*d*), 'Member Handbook', CLS Bank International, december.

CLS (2006), 'Company Homepage', http://www.cls-group.com, march.

CPSS (1990), Report of the Committee on Interbank Netting Schemes of the Central Banks of the Group of Ten countries, Lamfalussy-Report, Bank for International Settlements.

CPSS (1993), Central Bank Payment and Settlement Services with Respect to Cross-Border and Multi-Currency Transactions, Noel-Report, Bank for International Settlements.

CPSS (1996), Settlement Risk in Foreign Exchange Transactions, Allsopp-Report, Bank for International Settlements.

CPSS (1998), 'Reducing Foreign Exchange Settlement Risk: A Progress Report', Bank for International Settlements.

CPSS (2003), A Glossary of Terms used in Payments and Settlement Systems, Committee on Payment and Settlement Systems, ISBN 92-9197-133-2 (online).

CPSS (2005), 'Background Note', Bank for International Settlements.

CPSS (2007), 'Statistics on Payment and Settlement Systems in Selected Countries, Figures for 2005', Committee on Payment and Settlement Systems.

Credit Suisse (2004), 'Continuous Linked Settlement, White Paper: The Liquidity Crunch', Transaction Services & Solutions, july.

Cross, Sam (1998), 'The Foreign Exchange Market in the United States', Federal Reserve Bank of New York.

Dale, Richard (1984), *The Regulation of International Banking*, Prentice Hall.

Danmarks Nationalbank (2006), 'Payment Systems', http://www.nationalbanken.dk.

EBK (1998*a*), 'Continuous Linked Settlement', Swiss Federal Banking Commission, 19 march.

EBK (1998*b*), 'Void Disposition Risk for Creditors of Swiss Banks', Swiss Federal Banking Commission, 17 july.

Erdös, Paul & Alfred Rényi (1960), On the Evolution of Random Graphs, Publications, Mathematical Institute of the Hungarian Academy of Sciences.

Euromoney (2004), 'UBS and Deutsche race clear of the field', *Euromoney* **35**(421), 54–71.

Euromoney (2007), 'FX Poll 2007', *Euromoney* **38**(457), 170–178.

European Central Bank (2006), 'Large-Value Payment Systems', http://www.ecb.int.

European Central Bank (2007), 'From TARGET to TARGET2, Innovation and Transformation', http://www.ecb.int.

FED (2000), Intra-day Liquidity Management in the Evolving Payment System. A Study of the Impact of the Euro, CLS Bank, and CHIPS Finality, Payment Risk Committee, Federal Reserve Bank of New York.

FED (2003), 'Interagency Paper on Sound Practices to Strengthen the Resilience of the U.S. Financial System', Federal Reserve System, Doc No R-1128, 7 april.

Federal Reserve Bank of New York (2004), 'Average Daily Trading Volume of U.S. Treasury Securities', http://www.bondmarkets.com.

Franklin, Allen & Richard Herring (2001), Banking Regulation versus Securites Market Regulation, working paper series 01-29, Wharton School, University of Pennsylvania.

Garlaschelli, Diego, Stefano Battiston, Maurizio Castri, Vito Servedio & Guido Caldarelli (2005), 'The Scale-Free Topology of Market Investments', *Physica A* **350**, 491–499.

Geiger, Hans (2007), Banking: Clearing/Settlement/Zahlungsverkehr, Lecutre at the University of Zurich, http://www.isb.uzh.ch.

Geiger, Hans & Klaus Spremann (1998), *Banktopologie*, Verlag Paul Haupt.

Guonan, Ma, Corrine Ho & Robert McCauley (2004), The Markets for Non-Deliverable Forwards in Asian Currencies, Quarterly Review, Bank for International Settlements.

Herring, Richard (1993), 'BCCI: Lessons for International Bank Supervision', *Contemporary Policy Issues* (Vol. XI).

Herring, Richard (2003), 'International Financial Conglomerates: Implications for Bank Insolvency Regimes', Wharton School, University of Pennsylvania.

Hong Kong Yearbook (2005), 'Financial Services in Hong Kong', http://www.yearbook.gov.hk.

Inaoka, Hajime, Takuto Ninomiya, Ken Taniguchi, Tokiko Shimizu & Hideki Takayasu (2004), Fractal Network Derived from Banking Transaction - An Analysis of Network Structures Formed by Financial Institutions, Working Paper No. 04-E-04, Bank of Japan.

Iori, Giulia, Giulia De Masi, Ovidiu Vasile Precup, Giampaolo Gabbi & Guido Caldarelli (2005), A Network Analysis of the Italian Overnight Money Market, Discussion Paper Series 05/05, City University London, Department of Economics.

Japanese Bankers Association (2003), 'Payment Systems in Japan', http://www.zeninkyo.or.jp.

Kahn, Charles & William Roberds (1998), 'Payment System Settlement and Bank Incentives', *The Review of Financial Studies* **11**(4), 845–870.

Klein, Fritz (2006), 'Interview regarding Contracts for Difference', November 2006.

Lublóy, Ágnes (2006), Topology of the Hungarian Large Value Payment System, Occasional Papers 57, Magyar Nemzeti Bank.

Milgram, Stanley (1967), 'The Small World Problem', *Psychology Today* **2**, 60–67.

Monetary Authority of Singapore (2006), 'New MAS Electronic Payment System', http://www.mas.gov.sg.

Newman, Mark (2003), 'The Nature and Function of Complex Networks', arXiv:cond-mat/0303516v1.

Newman, Mark (2004), 'Analysis of Weighted Networks', arXiv:cond-mat/0407503 v1.

Newman, Mark, Albert-Lázló Barabási & Duncan J. Watts (2006), *The Structure and Dynamics of Networks*, Princeton University Press.

Niederer Kraft & Frey (2000), 'Continuous Linked Settlement', 14 january.

Norges Bank (2006), 'Payment Systems', http://www.norges-bank.no.

Pagè, Henry & David Humphrey (2005), Settlement Finality as a Public Good in Large-Value Payment Systems, Working Paper Series, No. 506, European Central Bank.

Perold, André (1995), *The Payment System and Derivative Instruments*, In: The Global Financial System: A Functional Perspective, Harward Business School Press Boston Massachusetts, pp. 33–79.

Pool, Ithiel de Sola & Manfred Kochen (1978), 'Contacts and Influence', *Social Networks* **1**, 1–48.

Price, Derek de Solla (1965), 'Network of Scientific Papers', *Science* **149**, 510–515.

Rapoport, Anatol & Ray Solomonoff (1951), 'Connectivity of Random Nets', *Bulletin of Mathematical Biophysics* **13**.

Remolona, Eli (1990), 'How Safety Nets Work: Dealing with Financial Institutions in Distress: The Experience of Four Countries', *Central Banking* (2).

Reserve Bank of Australia (2006), 'RITS Session Times and Operational Arrangements', http://www.rba.gov.au.

Reserve Bank of New Zealand (2006), 'Exchange Settlement Account System', http://www.rbnz.govt.nz.

Riedl, Gerald (2002), *Der bankbetriebliche Zahlungsverkehr*, Dieter Bartmann, Bankinformatik-Studien, Physica-Verlag, pp. 57-104.

Ripatti, Kirsi (2004), Central Counterparty Clearing: Constructing a Framework for Evaluation of Risks and Benefits, Discussion Paper, Financial Markets Department, Bank of Finland.

Roach, Pierre (2003), 'LVTS - Canada's Solution for High Value & Time Sensitive Payments', Canadian Payment Association.

Rossi, Eliana & Peter Taylor (2005), 'Banking Networks across Brazilian Cities: Within and Beyond Brazil', *Cities* **22**(5), 381–393.

Sawyer, David (2004), 'Continuous Linked Settlement and Foreign Exchange Settlement Risk', Financial Stability Review, december.

SEC (2006), Interagency Paper on Sound Practices to Strengthen the Reslilience of the U.S. Financial System, US Securities and Exchange Commission, http://www.sec.gov.

SFRC (1991), 'Statement No. 74: Bank of Credit and Commerce International', Shadow Financial Regulatory Committee.

Soramäki, Kimmo, Morten Bech, Jeffrey Arnold, Robert Glass & Walter Beyeler (2006), The Topology of Interbank Payment Flows, Staff Report no. 243, Federal Reserve Bank of New York.

South African Reserve Bank (2006), 'Payment & Settlement Systems', http://www.reservebank.co.za.

Sveriges Riksbank (2006), ‘Financial Infrastructure’, http://ww.riksbank.com.

SWIFT (2006), ‘Products & Services’, http://www.swift.com.

TowerGroup (2004), ‘The Continuous Linked Settlement (CLS) System: Building for Tomorrow Through Today’s Innovations’, TowerGroup 2004 CLS Survey.

Travers, Jeffrey & Stanley Milgram (1969), ‘An Experimental Study of the Small World Problem’, *Sociometry* **32**, 425–443.

UBS (2007), ‘UBS Annual Report: Handbook 2005/2006’, http://www.ubs.com, june.

Watts, Duncan & Steven Strogatz (1998), ‘Collective Dynamics of Small-World Networks’, *Nature* **393**, 440–442.

Curriculum Vitae

Alexandra Schaller, born April 13, 1978 in Berne, studied Finance at the University of Zurich (Switzerland) and Tulsa (USA). She finished her studies at the end of 2003 and worked in the consulting and food industry thereafter. In 2005, she returned to the University of Zurich in the position of a research assistant at the Swiss Banking Institute.